DOCUMENT RESUME

ED 413 243 SE 060 846

TITLE	Mathematics and Science Content Standards and Curriculum Frameworks: States Progress on Development and Implementation, 1997.
INSTITUTION	Council of Chief State School Officers, Washington, DC. State Education Assessment Center.
SPONS AGENCY	National Science Foundation, Arlington, VA. Directorate for Education and Human Resources.
ISBN	ISBN-1-8884037-36-4
PUB DATE	1997-00-00
NOTE	154p.
CONTRACT	REC-95-54462
AVAILABLE FROM	Council of Chief State School Officers, Attn: Publications, One Massachusetts Avenue, N.W., Suite 700, Washington, DC 20001-1431 ($18).
PUB TYPE	Reports - Evaluative (142)
EDRS PRICE	EDRS Price MF01 Plus Postage. PC Not Available from EDRS.
DESCRIPTORS	Curriculum Research; Educational Change; Elementary Secondary Education; *Mathematics Education; National Curriculum; *Science Education; *Standards; State Curriculum Guides
IDENTIFIERS	Council of Chief State School Officers

ABSTRACT

The Council of Chief State School Officers (CCSSO), collaborating with Policy Studies Associates and a panel of experts in mathematics and science education, has completed a study of states' curriculum frameworks development and standards-setting from 1994. The Council study analyzed the content and quality of state frameworks and standards documents and examined how states are working with local educators on implementation. This report describes the changing landscape of framework development and standards-setting in the United States and identifies emerging issues for practitioners and policy makers. The study was conducted with three kinds of data concerning the current situation of state standards and frameworks in mathematics and science. A concept mapping analysis of all state curriculum frameworks and standards documents in mathematics and science was completed. In order to identify all current state documents, works in progress, and dissemination and implementation activities, interviews were held with state mathematics and science education specialists. With the aggregated information from these sources, a report that focuses on current and emerging policy issues pertaining to the implementation of standards-based reform in mathematics and science education was developed. Contains 27 references. (Author/ASK)

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Mathematics and Science Content Standards and Curriculum Frameworks

States Progress on Development and Implementation

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Council of Chief State School Officers
State Education Assessment Center

Mathematics and Science Content Standards and Curriculum Frameworks

States Progress on Development and Implementation

1997

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The Study is supported by a grant from the National Science Foundation, Education and Human Resources Directorate, Division of Research, Evaluation, and Communication.

The Council of Chief State School Officers (CCSSO) is a nationwide, nonprofit organization of public officials who head departments of elementary and secondary education in every state, the District of Columbia, the Department of Defense Education Activity, and five extra-state jurisdictions. CCSSO seeks its members' consensus on major education issues and expresses their view to civic and professional organizations, to federal agencies, to Congress, and to the public. Through its structure of standing committees and special task forces, the Council responds to a broad range of concerns about education and provides leadership on major education issues.

The State Education Assessment Center is a permanent, central part of the Council of Chief State School Officers. This Center was established through a resolution by the membership of CCSSO in 1984.

The CCSSO Study of State Mathematics and Science Standards and Frameworks was conducted through the cooperation of the state departments of education. The study report is intended for use by state policymakers, developers of state content standards and curriculum frameworks, science and mathematics educators, professional education organizations, and federal agencies. The study was supported by a grant from the National Science Foundation, Division of Research, Evaluation, and Communication of the Education and Human Resources Directorate (#REC 95-54462). The views or conclusions expressed in the report do not necessarily reflect the position of the National Science Foundation.

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ISBN # 1-884037-36-4

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Acknowledgments

The CCSSO study of state standards and frameworks in mathematics and science is a cooperative effort involving a number of organizations and individuals.

We were fortunate to receive expert advice and assistance at several key points in the study. Science and mathematics educators, state education specialists, and education researchers from across the country provided a solid foundation for the study by guiding our study design and our analysis of standards and frameworks.

A panel of experts met for several days to review and analyze current state standards and frameworks, and to identify issues for their development, application, and use. These individuals willingly provided time and expertise and worked together to reach consensus on complex issues. We are very appreciative of the contributions of the panelists for our 1994-96 study: Charles Allan, Adrienne Bailey, Margaret Bondorew, Donald Chambers, Benjamin Dixon, Charles Doyle-Warren, Joan Ferrini-Mundy, Andrea Keim, Gerald Kulm, Connie Lauglin, Megan Martin, Curtis McKnight, Michael Oliver, Harold Pratt, Helen Quinn, Cathy Seeley, Norman Webb, Catherine Wilcoxson, and Abbie Willetto.

State science and mathematics supervisors were very cooperative in providing copies of their frameworks and related state documents, responding to interview requests, organizing state education teams, and reviewing study drafts. The study would not have been possible without the timely cooperation of professional staff in all of the states. We particularly thank the state education departments, state specialists and local educators who participated in our standards and frameworks review process. The in-depth discussions with state representatives provided a solid basis for understanding the current status of state mathematics and science standards and the issues in states concerning their development and application.

The study was funded through a grant from the National Science Foundation, Education and Human Resources Directorate, Division of Research, Evaluation, and Communication. We very much appreciate the support and guidance of our project officer, Larry Suter, and the advice and assistance from other NSF staff, including Janice Earle, Julio Lopez-Ferraro, and Susan Gross. The study was designed in cooperation with the U.S. Department of Education's evaluation of the Eisenhower State Curriculum Frameworks projects.

The Council staff was assisted in conducting the 1994-96 study by staff of three organizations. Ellen Pechman and David Goldstein at Policy Studies Associates, Washington, DC, led the survey data collection with states and the concept mapping analysis. Dan Humphrey and Patrick Shields, SRI International, Menlo Park, CA, collaborated with us in selecting the study's expert panel and in conducting the qualitative review of state standards and frameworks. Andrew Porter, director of the Wisconsin Center for Education Research, consulted with us on the study design and organized resources and facilities for the work of our expert panel. At CCSSO, Barbara Kapinus and Edward Roeber of the Council staff offered key assistance and technical advice to the Study, and they provided important leadership with our expert panel review.

Executive Summary

States Progress on Standards and Frameworks in Mathematics and Science Education: Study Findings

The Council of Chief State School Officers, collaborating with Policy Studies Associates and a panel of experts in mathematics and science education, has completed a study of states' curriculum frameworks development and standards-setting since 1994. The Council study analyzed the content and quality of state frameworks and standards documents and examined how states are working with local educators on implementation. The study builds on and extends our previous study of states' development of curriculum frameworks from 1990 to 1994. This report describes the changing landscape of framework development and standards-setting in the United States and identifies emerging issues for practitioners and policy makers.

The study was conducted with three kinds of data about the current situation of state standards and frameworks in mathematics and science. We completed a "concept mapping" analysis of all state curriculum frameworks and standards documents in mathematics and science, with emphasis in the present report on those developed or revised since 1994. Project staff interviewed state mathematics and science education specialists between April and July 1996 to identify all current state documents, works in progress, and dissemination and implementation activities. A panel of experts identified by the Council completed in-depth, qualitative reviews of new state standards and frameworks from 16 states. With the aggregated information from these sources, we have written a report that focuses on current and emerging policy issues pertaining to the implementation of standards-based reform in mathematics and science education.

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How Standards Were Developed

- **Forty-six states completed mathematics and science standards.**

  At the end of 1996, 46 states had developed a document, or documents, creating or updating their content state standards for mathematics and science education. Thirty-two of these states completed their standards document between November 1994 and December 1996. Almost all of the remaining 14 states completed their standards or frameworks from 1990 to 1994. *See Chapter Two for current development.*

- **Three approaches were used in standards development: (a) state framework, (b) content standards, (c) content standards plus supplementary documents for educators.**

  Some states produced a standards-only document, while other states incorporated further substantive information in their standards or framework documents—covering teaching and curriculum examples, equity principles, assessment standards, professional development models, and recommendations on instructional materials. Some states use a combination of the three to guide their movement towards standards-based reform of mathematics and science education.

- **Standards were shaped by educators, officials, and public.**

  States had broad involvement of educators and subject specialists in the development of state curriculum frameworks and standards. State standards or frameworks documents are also shaped by elected officials and the public. The broad review and approval process for standards in many states helps to build familiarity,

legitimacy, acceptance and use of standards within states. The process has sometimes led to compromise between current education practices and the vision and goals set out by leaders in professional mathematics and science communities.

- **Consistent, on-going process is needed.**

  States need a consistent, continuing message from policy makers and education leaders on using state standards for mathematics and science as the basis for education improvement in their states. States will need to continue offering leadership, expertise with standards, and funding support.

State Standards Links to National Professional Standards

- **Main categories of state standards are similar to national.**

  Most states incorporated the main standards categories of the national professional standards into state documents. Terminology, level of detail, extent of explanation of standards, and use of examples and other information differ among states. *See Chapter Five for state-by-state examples.*

  In mathematics, almost all states have standards that cover mathematics content recommended by NCTM Standards in the areas of numeration and number operations, measurement, functions, geometry, statistics and probability, problem solving, reasoning, communication, and connections.

  In science, almost all states have standards that cover science content recommended by NRC Standards and AAAS Benchmarks in areas of scientific inquiry, life science, physical science, earth science, and applications of science.

- **State standards include subject content and expectations for students; expectations differ markedly by state.**

  Some states specify the level of expected performance or knowledge across content topics; others states have more general statements of expectations; while still others list overall process skills as themes for curriculum and instruction. Imprecise, poorly-worded expectations are a problem in some state frameworks and standards.

- **Standards have potential to focus curriculum and reduce breadth.** If state standards are implemented, they will increase the focus of mathematics and science curriculum, a goal for U.S. education suggested by TIMSS results.

- **State mathematics standards give a strong, consistent push for greater emphasis on higher level mathematics for all students, and less differentiation of curriculum for different groups of students.** For example, many states recommend incorporating some aspects of measurement, geometry, data and statistics, algebra, problem solving and reasoning into all elementary and middle grades mathematics. *See Chapter Five for standards by state.*

- **State science standards emphasize active hands-on student learning and doing of science.** This approach has not typically been found in elementary and middle grades science or in all high school science. States advocate scientific inquiry and place emphasis on big ideas and concepts in life, physical, and earth science throughout K-12 science education.

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Key Contributors to Quality of State Standards

- **Rigorous, challenging statements of content and clear, specific expectations**

  State mathematics and science standards do recommend challenging subject content. Benchmarks for each standard need to provide specific expectations of student learning appropriate for grade level, and some states need further work on benchmarks. Some are too general or vague. Some states lack consistency in the degree of rigor across different standards.

- **Communicate how standards link to education improvement.**

  Standards can give an adequate starting point for developing teaching strategies, writing curricula, and raising expectations for students. However, they must be substantively rich and provide clear ideas and examples about how teaching and learning would change, if they are to move instruction beyond traditional, fact-driven and memorization approaches to mathematics and science education. Some state documents are weak in this communication. *See Chapter Three for state methods of communication.*

- **Strategies toward equity are needed.**

  Equity and inclusion in mathematics and science curriculum and opportunities are typically given as state goals; however most states have not provided standards for determining progress toward the goals. State standards documents commit to applying the standards equally to all racial/ethnic, gender, and disability groups. The review panel found only a few good examples of how current school curriculum and school organization will need to change to reach the state's vision.

- **Teaching, assessment, program standards**

  States all recommend a set of "content standards," but less than 10 states address teaching standards, assessment standards, or program or system standards. Many states provide examples of teaching practices and strategies and examples of student assessment exercises that would be consistent with content standards. *See Chapter Three for analysis of state documents.*

Implementation of State Standards and Frameworks

- **Strategies and quality examples can help demonstrate curriculum change.**

  Two-thirds of states provide some curriculum examples, classroom activities, or vignettes to communicate how content standards can be applied in school curriculum. Examples for local curriculum need to be of high quality.

- **Extended state support is needed for standards implementation.**

  State education leaders see long-term needs for support of standards with schools. States vary widely in strategies for implementation of standards or frameworks, and how they will be used with schools and educators. The primary implementation strategies reported by states are: professional development workshops, local sessions on writing curriculum, regional networks within states, and Internet Web sites. Also, states are working to revise certification standards for teachers and state assessment programs. *See Chapter Four for state dissemination and implementation strategies.*

- **Assessments should align with standards.**

  The content standards recommended by states call for change in methods of assessing learning. In 1996, over half the states did not have state assessments that are based on current standards. *See Chapter Two for state-by-state information.*

- **Performance standards and levels are still in development.**

  Performance standards, or levels, are needed to link standards for student learning to new assessments. States use the term "performance standards" in two different ways (a) as benchmarks or indicators, i.e., more detailed expectations under the content standards, and (b) as levels of expected performance on student assessments. Most states are still working on performance standards.

- **Professional development plans are needed in many states.**

  States are likely to need long-term plans for professional development and pre-service education with teachers and administrators, and funding from states and other sources to continue to progress with standards. Only one-third of states standards and frameworks directly address professional development or teacher education in their state document. *See Chapter Three for states with professional development plans.*

Chapter One

Overview of State Content Standards and Curriculum Frameworks in Mathematics and Science: Summary of Findings and Issues

Introduction: National and State Initiatives

Since the late 1980s, states have worked to develop "curriculum frameworks," "content" and "performance" standards, and student assessments using various alternative response formats to reflect updated goals and content for mathematics and science education set out by national professional organizations and many education reform advocates. Known as "standards-based reform," the assumption behind these initiatives is that articulating clear educational standards to indicate what children "should know" and "be able to do" is a fundamental first step toward improving the nation's mathematics and science education (Smith & O'Day, 1991; NCEST, 1992; Shanker, 1994; Porter, 1994). By defining and disseminating agreed-on expectations, the nation's students are more likely to be assured a common, rigorous, modernized curriculum regardless of where in the nation they attend school.

A number of high-level groups nationally have endorsed this approach to improving education in the United States. The nation's Governors—in education summits—held first in 1989 and then again in 1996—established a strong commitment to articulating high expectations and redefining the standards students in their states should achieve. In 1994, Congress—through initiatives such as the Improving America's Schools Act (IASA) and Goals 2000—lent credibility and clout to the standards-based reform movement by linking the availability of federal funds to states' willingness to define standards and curriculum frameworks, measure their achievement, and hold all students accountable for achieving them. The National Science Foundation has funded systemic reform initiatives for mathematics and science with states, cities, and rural collaboratives. Finally, professional discipline-based organizations have defined and widely disseminated "content standards" that reflect the current thinking of the nation's teachers, researchers, and curriculum experts. The disciplines of mathematics and science led the nation's standards-setting through the publication of core curriculum, teaching, and assessment standards between 1989 and 1995. The National Council of Teachers of Mathematics (NCTM, 1989, 1991, 1995), the National Academy of Sciences/National Research Council (NRC, 1995), the American Association for the Advancement of Science (AAAS, 1993), and the National Science Teachers Association (1992) each published curriculum and standards-setting models within their disciplines. State and local education agencies have built on these efforts and have used these discipline-based resources to modernize the mathematics and science education they expect of students in their school systems. Many education leaders, policy makers, and reform advocates view the state curriculum frameworks and standards as significant signals to educators and communities that mathematics and science education must and will be substantively upgraded and modernized and that ambitious expectations hold for all children, not just an elite few.

The Council of Chief State School Officers (CCSSO) has been active in the move toward content standards and frameworks, and we work with education leaders, curriculum experts, and researchers to assist states. As part of our assistance to states, the Council has produced several kinds of state-by-state reports. The Council organized conferences and workshops on state development of content and performance standards across core academic subjects, and then charted states' progress (CCSSO/Curriculum & Instructional Improvement Project, 1996). We surveyed states and reported on the status of state systemic education developments un-

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der Goals 2000 (CCSSO/State Leadership Center, 1996). A series of biennial Council reports track changes in state education policies on K–12 education, with the most recent in 1996 focusing on standards, course requirements, student assessments, and teacher licensure (CCSSO/State Education Assessment Center, 1996). The Council also established an Internet Web Page (www.ccsso.org) that lists Council reports and provides direct access to state-by-state information on state policies and on science and mathematics standards and frameworks included in this print document.

Purpose and Design of Study

The present study of science and mathematics standards and frameworks continues work that began in 1993. Under a grant from the National Science Foundation, the Council conducted an initial study of the development of state curriculum frameworks from 1990 to 1994 (Blank and Pechman, 1995). We reported that half of the states had completed new state curriculum frameworks, or other state science or mathematics guidelines, between 1990 and 1994.

The present report, based on the past two years' work, charts progress of more states' efforts to develop "content standards" or "curriculum frameworks". State standards and frameworks are based on state support and policy initiatives and incentives from federal education legislation—IASA, Goals 2000, NSF's State Systemic Initiatives, Eisenhower Mathematics-Science Frameworks grants.

The CCSSO study, supported by the National Science Foundation (NSF), reflects effective collaboration among the research staff, a panel of mathematics and science education experts, and states' mathematics and science curriculum specialists. The Council's design for analyzing the characteristics, or "elements," and quality of state content standards and curriculum frameworks was developed in conjunction with evaluation studies of frameworks and standards for the U.S. Department of Education conducted by SRI International and Policy Studies Associates (PSA) (Humphrey, Shields, & Anderson (1995), and Humphrey & Shields (1996)). Other recent studies of state standards were conducted by American Federation of Teachers (1996) and Consortium for Policy Research in Education (Massell et al., 1997).

Four research questions are addressed in this study:

- What is the current status of standards-setting and curriculum framework development in mathematics and science across the United States?
- To what extent are the states' frameworks and standards consistent with national professional mathematics and science education standards and what variations occur?
- How do states organize and present the standards and frameworks to communicate to various audiences about modernizing mathematics and science curriculum content, pedagogy, and materials, and upgrading facilities and resources?
- What criteria should be used in judging the quality of new state standards and frameworks?

The study design has three major components: (1) a descriptive analysis of the frameworks' mathematics and science content using a "conceptual mapping" strategy that was developed and applied successfully in our prior study of curriculum frameworks (Blank & Pechman, 1995); (2) in-depth interviews with content specialists who spearheaded standards and framework development in the states; and (3) qualitative reviews of state standards, frameworks, and related materials based on the quality judgements of an expert panel of mathematics and science curriculum specialists, school and district-level educators, and researchers (see Appendix A for further information on study design and a list of expert panelists). Key sources for the analytical framework in all study components are the NCTM *Curriculum Standards for Mathematics Education* (1989), the AAAS *Benchmarks for Science Literacy* (1993), and the NAS/NRC *National Science Education Standards* (1995).

Content standards –

Specify the content knowledge and skills all students will know and be able to do upon completing particular grades or courses in K–12 education; the content standards state clearly the knowledge and skills to be learned, and at what developmental level content is to be presented.

Performance standards –

Specify how good is "good enough"—usually in conjunction with a method of assessment—and gauge the degree to which content standards have been attained by individuals or groups, indicating the nature of the evidence and the quality of student performance on agreed upon tasks or measurement instruments.

Curriculum framework –

A document published by a state education agency or state board of education that includes desired subject content or standards for a core academic subject in K–12 education, and written by a team of content experts, state agency personnel, and local educators. A state framework often serves as a bridge between national professional standards and local curriculum and instructional strategies, and may address areas of pedagogy, classroom examples and vignettes, strategies toward equity, and important education policies and school conditions.

Effects of State Context on Development of State Standards and Frameworks

- Three state approaches
- Broad involvement
- Standards shaped by officials and educators
- Consistent, on-going process

At the end of 1996, 46 states had developed a document, or documents, creating or updating their content standards for mathematics and science education. In completing these state initiatives, states made a substantial step in moving toward "standards-based reform." The CCSSO study team analyzed the contents of these documents, conducted interviews with state education staff, and convened an expert panel to examine issues about the quality of state standards and related materials. From this work, what can be said about how these documents differ across the states? How has the state context affected development of standards and frameworks?

Three State Approaches to Standards

- State framework
- Content standards
- Content standards and supplementary documents

This typology characterizes the types of materials states wrote and published as they moved towards standards-based reform. *See Chapter Two for a list of the states' published standards and frameworks.*

(1) **State curriculum framework:** A framework is a document specific to a subject, such as mathematics or science, that includes state content standards for what students should know and be able to do, as well as classroom examples or vignettes illustrating use of standards in curriculum and instruction, discussion of pedagogy related to standards, student assessments consistent with standards, and descriptions of links between standards and professional development, teacher education, and other state and local policies.

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Of 34 states' standards and frameworks documents reviewed by CCSSO/PSA in 1996, 15 states produced broadly-focused frameworks that include both standards and the state's vision for upgrading mathematics and science education. The frameworks include vignettes, examples of activities and tasks, and guidelines for developing curricula. Some frameworks model mathematical and science learning as dynamic human activities that assume learning involves thinking, experimentation, analysis, and drawing and communicating conclusions. As examples, frameworks of Kentucky, Michigan, and Massachusetts are layered resources that open with streamlined sets of content standards and outcomes, and chapters unfold that detail suggestions for practice, including specific activities or tasks and vignettes that convey new experimental or practical pedagogical approaches. Other examples of states recently completing curriculum frameworks in mathematics and science are Alaska, Arkansas, Delaware, Indiana (mathematics), Maine, Missouri, Nebraska, Ohio, Rhode Island, and South Carolina.

(2) **Content standards**: A standards document, or closely linked series of documents, that includes the standards for student learning in K–12 education for academic subjects—language arts/English, mathematics, science, social studies, arts, health.

These documents focus on broad standards statements for each core subject plus benchmarks, or indicators, by grade or grade cluster. They typically do not include curriculum or instructional examples or discussion of pedagogy or related policies. Some states have written expectations for student cognitive development, e.g., understanding, problem solving, communicating, that are common across subjects. Recent examples of this approach to standards are Illinois, North Dakota, Oregon, Virginia, Washington, West Virginia, and Wisconsin.

(3) **Content standards plus supplementary documents for educators:** About 10 states' recent standards strike a middle position between streamlined standards and comprehensive frameworks. These states plan to supplement their standards document with additional guidance for teachers that depicts a picture of reform expectations through vignettes and descriptions of tasks or activities teachers undertake at benchmark grades. Recent examples of this approach are Colorado, Louisiana, Michigan, Mississippi (mathematics), New Jersey, New Mexico, New York, South Dakota, Texas, and Vermont.

States such as Colorado, Louisiana, and Texas anticipate developing more lengthy interpretive supplements to enrich the core ideas summarized in the standards statements once the standards statements are agreed to by advisory committees and go through the statewide approval process. These supplemental documents are developed, or planned, to assist educators in developing curriculum, designing instructional activities and assessments, and implementing the standards. These documents are not developed as part of state policy, but are supported by state efforts to guide teachers or curriculum specialists in applying the standards to schools and classrooms.

Varying Policies and Goals

In New Mexico and Ohio, the standards are part of the state's education code, and, once established, are difficult to change. To avoid restrictive interpretations of standards, the state leaders in these states cast the language of the standards broadly so they can be widely understood and agreed to, but they leave out instructional directions. Similarly, performance standards, which few legislatures mandated, are being written in a later phase of standards development, when the standards can be keyed to the states' assessments.

In general, we can see states have used an array of approaches to standards-setting and curriculum frameworks development in science and mathematics. Standards—the goals a state is trying to achieve in core academic subjects, and frameworks—the resources and guidance on how to achieve the standards—differ in scope and detail. Some states, such as Alaska, Delaware, Kentucky, Maine, and Rhode Island have designed frameworks and materials aimed towards changing teachers' practices and strat-

egies: "We attempted to get as far away as possible from the old scope and sequence," Alaska's developers report. *"We want teachers to (use this framework) to look at what to teach and when. We want teachers to inspire kids' interest, their desire to be lifetime learners."* Other states, such as Illinois, Colorado, and Texas, concentrate on using the standards as a means to engage the public and teachers in discussion that leads to a higher level of expectation for students.

In 1994, CCSSO found a pattern of states developing comprehensive frameworks that included state standards for mathematics or science in the context of extensive information for teachers and policy makers that developed understanding of how curriculum and instruction needs to change under standard-based reform. Sixteen states received funding from the U.S. Department of Education (ED) to develop curriculum frameworks in mathematics and these states completed documents that moved them toward the more comprehensive approach that included teaching, curriculum development, and criteria for selecting materials and resources. California, Florida, Nebraska, South Carolina, and Kentucky are examples of states that recommended organizational and programmatic changes to support new curriculum and implementation.

In 1996 we began to see a shift in the substance of states' guidance to districts. As of August 1996, 46 states had drafted standards in some form, but the emphasis on developing curriculum frameworks had shifted to a focus on content and performance standards first. A smaller proportion of states was moving toward "curriculum frameworks" as the main document recommending standards to districts and schools.

Broad Involvement in Development and Review

State initiatives in the 1990s to develop state standards and frameworks documents differ from earlier state efforts in several ways. First, the pattern across states is widespread involvement of local educators, community leaders, business groups, and political leaders in dialogue and review concerning what should be taught and learned in mathematics and science. We learned from interviews and document review that state content standards and frameworks received much broader local involvement than had been the pattern with prior state initiatives, such as statewide student assessments in the 1980s or curriculum guides in the 1960s through the 1980s.

States had broad involvement of educators, subject specialists, and communities in the development of state curriculum frameworks and standards.

A second development in the 1990s is active involvement of classroom teachers in writing and editing content standards and frameworks in mathematics and science. A common practice for states in producing standards documents is to convene a large steering committee or task force which represents educators, administrators, subject specialists, and community leaders from across the state. Teachers from all grade levels have typically formed the core of smaller writing teams to develop and draft standards statements, provide examples, and determine appropriateness for application in classrooms. For states with active teacher writing teams, the standards-setting process has the beneficial effects of building subject knowledge of educators and strengthening professional networks. It also developed new alliances among educators and the public, as they jointly defined the directions for mathematics and science education for children.

Many states were planning to ensure public editions of the standards would be available in easily understood, jargon-free documents that would appeal to a highly diverse audience. State departments of education report that getting the standards squared with state and local expectations is the first stage of development. In later stages, states are convening educators to write supplemental supporting materials that will guide districts and schools in the development of local standards and guidance to classroom implementation. The audiences for plain-talk standards are school boards, communities, and parents; teachers, principals, and curriculum specialists are the audiences for the extended frameworks.

Standards Shaped by Officials and Educators

Most state standards or framework documents are approved by state boards of education, state standards commissions, or elected officials. The process of review often includes public hearings, discussions with elected officials and their staff, and suggestions from many groups of educators, business and community leaders, and parents.

In many states, the current standards or framework document is the first statewide document recommending what students should know and be able to do in these subjects, and this process in mathematics and science becomes a model for other subjects. For example, in Alaska, Colorado, Maine, and South Dakota, the state traditionally left decisions about goals for student learning or curriculum development to local districts, schools, and teachers. In these states, the role of the state in convening and leading the standards or framework process had to be clarified and accepted.

State standards documents are shaped by elected officials and the public as well as by substantive experts and education leaders.

States such as Florida, Illinois, Louisiana, and New York had prior state curriculum guides or course syllabi. In these states, the standards or framework approach produced a different role for state curriculum specialists and leaders because the standards were aimed at setting high challenging targets for students as opposed to minimum or basic requirements for a grade, course, or test. Furthermore, in these states, the challenge was to move away from prescribing detailed objectives, and to develop local capacity to write the curriculum that would implement the emerging standards.

Interviews with state mathematics and science supervisors raised the concern that the state approval process contributed to narrowing the vision of curriculum content standards and frameworks to create a "standards-only" approach. The major audiences and reviewers of frameworks designed in the early 1990s were educators and curriculum experts, but, at various points prior to adoption, parents and community members—and sometimes state or local school board members—were added to committees. As frameworks and standards-setting gained greater visibility, policy makers and voters have become more significant audiences to which standards are targeted. On the other hand, in a few states educators have sought to keep the standards out of the limelight: "Our state board does not know the document exists ... it is on the Internet (and being used in staff development with teachers), but it will not be published."

The review and approval process involving many educators, political leaders, and the public helps to build familiarity, legitimacy, acceptance and use of standards within states. From the viewpoint of experts in the fields of mathematics and science education in states, the process has some drawbacks, as well. It often leads to compromise between current understandings and education practices and the vision and goals set out by leaders in professional communities, such as represented by the national professional standards. For example, the strong emphasis on mathematics as "problem-solving" in the NCTM standards became mathematical "applications" in one state document. In New Jersey, the 1993 mathematics standards written by mathematics educators were revised to make them more content-oriented, and less focused on cross-cutting capacities of students. The new standards are linked to preparing all students for transition to work, and in the process, the emphasis on mathematics problem solving as "intellectually stimulating and engaging" became more of an essential skill.

Vocal local political constituencies in some states view the national professional standards with suspicion. Even in states where the professional educators strongly back the national standards, they decided to make their endorsement implicit rather than explicit. A state leader whose professional colleagues fully back the NCTM/NRC standards has closely monitored the standards development to incorporate as much as possible from the national standards into her state's. However, she pointed out

that "the last thing we can do is reference the national documents. We need to distance ourselves as far as possible from the national standards."

The process of developing and approving standards and frameworks is constructive in all states in that the process involves educators, leaders, and the public in considering whether the current expectations for K–12 education are too low or not consistent for all students. In many states, the new language and approach of standards clearly produced higher goals and expectations for student performance, but in other cases, national professional standards were adapted and revised in order to meet state concerns about the implications of "standards" and concerns about how much change could be expected of local educators.

Consistent, On-going Process

The state teams participating in the 1996 standards/frameworks review reported they are continuing to work toward the goal of using state standards for mathematics and science as the basis for education improvement in their states. They view the "standards movement" as a long-term process that will only be maintained with substantial continuing support and resources from the states and encouragement from professional and policy organizations.

States need a consistent, continuing message about standards-based mathematics and science education. States also need to maintain support for standards-based reform and leadership by math and science specialists.

The message of continuity can be supported through the statements, reports, and work of national organizations such as NCTM, the National Science Teachers Association, CCSSO, and the National Governor's Association to help maintain a nonpolitical, professional-based motivation behind standards and frameworks. The message about the central role of standards and frameworks needs to be directed to states but must also come from local districts and school-based professional organizations.

State leaders need to continue to reinforce the importance of pursuing work on implementation of standards. State leaders also need to continue to assist local educators in developing and implementing standards, to provide state staff that have expertise in mathematics and science, and to support professional development for educators on standards.

State Standards and Frameworks Link to National Professional Standards

- Main categories of state standards similar to national
- Standards include topics plus expectations
- Focus curriculum, reduce breadth

In reviewing the standards and frameworks documents completed since 1994, CCSSO found that the national professional standards completed by NCTM (Curriculum and Evaluation Standards for Mathematics Education, 1989), AAAS (Benchmarks for Science Literacy, 1993) and by the NRC (National Science Education Standards, 1995) were referenced, used, and adapted by the states. Although most states have completed a state standards document for mathematics and science, they have not adopted the same standards language or text used in national professional standards documents.

Main State Standards Similar to National

Most states incorporated the main standards categories of the national professional standards into state documents, but the terminology, level of detail, and extent of explanation of standards differ among states.

Results of CCSSO's concept mapping analysis of 34 state standards documents show there is substantive continuity in the main categories and general organization of mathematics standards among state documents, but less for science *(See Chapter Three for a state-by-state listing of content standards and examples of standards and benchmarks)*. In general, states adapted or rephrased NCTM's *Curriculum Standards*, and either selected between NRC's *Science Standards* or AAAS' *Benchmarks* and then adapted the science content categories to state preferences and curriculum expectations.

Mathematics

In the main categories of state standards which typically cover K–12 or multiple grade levels, state standards have a high degree of similarity.

- Virtually all states have standards for numeration and number operations, measurement, functions, geometry, statistics and probability, problem solving, reasoning, communication, and connections.
- For early grades, states have followed the recommendations of NCTM by emphasizing measurement and geometry.
- In the middle grades, states emphasize algebra and statistics and probability. All but five states have organized their standards and benchmarks in grade clusters, similar to the K–4, 5–8, 9–12 clusters found in NCTM standards.
- At the high school level there is less consistency with NCTM—only a few states have followed the recommendations of NCTM for high school mathematics emphasis on trigonometric functions, discrete mathematics, and concepts of calculus.

Science

There is consistency across states in recommending standards that cover subject categories recommended by NRC Standards and AAAS Benchmarks.

- Scientific inquiry, life science, physical science, earth science, and applications of science are found in all states.
- At the same time, many states do not place a standards-level emphasis on science and technology, science in personal and social perspective, or history and nature of science.
- Some states have incorporated environmental science and nature of science as topics under other standards. Within the broad disciplines of life, physical, and earth science, many states have written more specific content standards.
- For example, in life science, all states specify students should learn concepts of cell, organism, and matter and energy. Some states have

excluded biological evolution or heredity in their standards.

Recent detailed analyses of subject content topics in state frameworks and content standards were conducted by Schmidt, et al., for the Third International Mathematics and Science Study (TIMSS) (1996); and the U.S. Space Foundation, (1996).

Differences

There are several ways state standards differ from the national documents. First, states have written their standards for mathematics and science using varying terminology. The term "standards" is expressed in Indiana as "proficiencies," in Louisiana as "strands," and in Kansas as "program outcomes." States also differ widely in the level of detail, specificity of benchmarks or indicators, and degree of explanation for their standards. Each state's standards reflect history and recent reforms, as well as the compromises that must be made in a public and professional review. States learned that defining their own standards is critical to gaining public acceptance of standards. *States generally started from the conceptual structure and emphases of national professional standards, but the process of development and approval produces differences in specific expectations for students.* Grade-level benchmarks reveal the degree to which challenging content and knowledge is spelled out for students, teachers, and curriculum writers, and the extent to which critical substantive and pedagogical reforms have taken hold.

Differences in the approach to writing standards can be illustrated by arraying an example from NRC *Science Standards* in the area of Life Science/Cell for grades 5–8 and several examples of state standards for this area.

From *NRC Science Standards*, pp. 155-157

Standard: Grades 5–8

Science

Life Science, Content Standard C: (p. 155)

As a result of their activities in grades 5–8, all students should develop understanding of

- Structure and function in living systems
- Reproduction and heredity
- Regulation and behavior
- Populations and ecosystems
- Diversity and adaptations of organisms

Developing Student Understanding

In the middle-school years, students should progress from studying life science from the point of view of individual organisms to recognizing patterns in ecosystems and developing understandings about the cellular dimensions of living systems. For example, students should broaden their understanding from the way one species lives in its environment to populations and communities of species and the ways they interact with each other and with their environment. Students also should expand their investigations of living systems to include the study of cells. Observations and investigations should become increasingly quantitative, incorporating the use of computers and conceptual and mathematical models. Students in grades 5–8 also have the fine motor skills to work with a light microscope and can interpret accurately what they see, enhancing their introduction to cells and microorganisms and establishing a foundation for developing understanding of molecular biology at the high school level.

Some aspects of middle-school student understanding should be noted. This period of development in youth lends itself to human biology. Middle-school students can develop the understanding that the body has organs that function together to maintain life. Teachers should introduce the general idea of structure-function in the context of human organ systems working together. Other, more specific and concrete examples, such as the hand, can be used to develop a specific understanding of structure-function in living systems. By middle-school, most students know about the basic process of sexual reproduction in humans. However, the student might have misconceptions about the role of sperm and eggs and about the sexual reproduction of flowering plants. Concerning heredity, younger middle-school students tend to focus on observable traits, and older students have some understanding that genetic material carries information.

Guide to the Content Standard

Life Science

Fundamental concepts and principles that underlie this standard include

Structure and Function in Living Systems (pp. 156-7)

- Living systems at all levels of organization demonstrate the complementary nature of structure and function. Important levels of organization for structure and function include cells, organs, tissues, organ systems, whole organisms, and ecosystems.
- All organisms are composed of cells—the fundamental unit of life. Most organisms are single cells; other organisms, including humans, are multicellular.
- Cells carry on the many functions needed to sustain life. They grow and divide, thereby producing more cells. This requires that they take in nutrients, which they use to provide energy for the work that cells do and to make the materials that a cell or an organism needs.
- Specialized cells perform specialized functions in multicellular organisms. Groups of specialized cells cooperate to form a tissue, such as a muscle. Different tissues are in turn grouped together to form larger functional units, called organs. Each type of cell, tissue, and organ has a distinct structure and set of functions that serve the organism as a whole.
- The human organism has systems for digestion, respiration, reproduction, circulation, excretion, movement, control and coordination, and for protection from disease. These systems interact with one another.
- Disease is a breakdown in structures or functions of an organism. Some diseases are the result of intrinsic failures of the system. Others are the result of damage by infection by other organisms.

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Examples of Content Standards and Benchmarks

ILLINOIS

Standard: Middle/Junior

Science

Apply concepts of form and function within the sciences: Life Sciences

(p. 14)

Benchmarks for this Standard

Compare and contrast how different forms and structures reflect different functions, e.g., identify similarities and differences among animals that fly, walk or swim; compare structures of plant cells to those of animal cells.

NEW MEXICO

Standard: Grades 5–8

Science

Life Science: Structure and Function of Living Systems, Knowledge and Characteristics of Organisms

Benchmarks for this Standard

1. Living systems at all levels of organization demonstrate complimentary relationships between structure and function.
2. All organisms are composed of cells, the fundamental unit of life.
3. Cells carry on many functions needed to sustain life.
4. Cells grow and divide, thereby producing more cells.
5. Cells take in nutrients which they use to power the work that cells do and to make the materials that a cell and organism needs.
6. Disease represents a breakdown in structure or function of an organism.

NEW YORK

Standard: Intermediate

Science

Students will understand and apply scientific concepts, principles, and theories pertaining to the physical setting and living environment and recognize the historical development of ideas in science.

(p. 33)

Benchmarks for this Standard

- Compare and contrast the parts of plants, animals, and one-celled organisms.
- Explain the functioning of the major human organ systems and their interactions.
- Describe sexual and asexual mechanisms for passing genetic materials from generation to generation.
- Describe simple mechanisms related to the inheritance of some physical traits in offspring.
- Describe sources of variation in organisms and their structures and relate the variations to survival.
- Describe factors responsible for competition within species and the significance of that competition.
- Observe and describe cell division at the microscopic level and its macroscopic effects.
- Compare the way a variety of living specimens carry out basic life functions and maintain dynamic equilibrium.

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Standards Include Subject Topics Plus Expectations for Student Knowledge and Skills

Across the states, content standards have a broader role and meaning than simply outlining the recommended content topics by grade level. Standards are written as statements that recommend and describe subject or discipline areas recommended (e.g., algebra, numeration, measurement, life science, earth science, matter and energy) as well as expectations for what students know and are able to do in the area of the subject (e.g., understanding concepts, problem-solving strategies in mathematics, methods of scientific inquiry, appropriate use of tools and technology).

The national professional standards documents in mathematics and science (NCTM, AAAS, NRC) clearly lay out the expected disciplinary knowledge students should gain, together with description of how students should be able to use, demonstrate, and integrate their knowledge.

States differ in how expectations are related to subject content, and how they are written. Some states clearly portray the kinds of knowledge and specify the level of expected performance across content topics; others have much more general statements of expectations; while still others only list "process skills" (e.g., problem solving, reasoning, connections) as overall themes for curriculum and instruction rather than as specific standards that students should meet. An expert review of state standards in 1996 found problems in some documents with imprecise, poorly worded statements of student expectations (Humphrey and Shields, 1996).

The three examples that follow show state's different approaches to standards and integration of content topics and expectations for students.

ALASKA

Combined Topics and Expectations in Standards

Standard

Content of Mathematics:

Understand mathematical facts, concepts, principles and theories.

Benchmarks for this Standard

- Numeration: Understand and use the concept of numbers, number systems, and numeration.
- Measurement: Select and use appropriate systems, units, and tools of measurement.
- Estimation and computation ...
- Functions and relations ...
- Geometry ...
- Statistics and probability ...

Problem solving:

Understand, select, and use a variety of problem solving strategies.

Benchmarks for this Standard

- Use computational methods and appropriate technology as problem-solving tools.
- Use problem-solving to investigate and understand mathematical content.
- Formulate mathematical problems that arise from everyday situations.
- Develop and apply strategies to solve a variety of problems.

Communication:

Understand, form and use appropriate methods to define and explain mathematical relationships.

Benchmarks for this Standard

- Express and represent mathematic ideas ...
- Relate mathematic terms to everyday language.
- Develop, test, and defend mathematic hypotheses.
- Clarify mathematic ideas through discussion.

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MASSACHUSETTS

Benchmarks Combine Content and Expectations

Standards: Grades 5–8

Science

Life Science: Characteristics of Organisms

(p. 62)

Benchmarks for this Standard

- Identify the cell as the basic unit of life and the smallest unit that can reproduce itself ...
- Explore and describe an understanding that plants, animals, fungi, and various types of microorganisms are major categories of living organisms ...
- Observe and explain that in single cells there are common features that all cells have as well as differences that determine their function ...
- Investigate and illustrate evidence that cell replication results not only in the multiplication of individual cells, but also in the growth and repair of multicellular organisms.
- Present data to illustrate that all organisms, whether single or multicellular, exhibit the same life processes, including growth, reproduction and the exchange of materials and energy with their environment.

LOUISIANA

Themes and Standards

Pervasive Themes

The vision of mathematics education in this framework is expressed through five pervasive and thoroughly interwoven themes which encompass the strands of school mathematics.

- **Mathematics as Problem Solving**

  Classroom instruction should focus on more diverse and complex problem-solving situations that arise from relevant, real-life circumstances. Students should be able to design problems and generate appropriate solutions.

- **Mathematics as Numerical Intuition**

  Students should develop a common-sense approach to using numbers, an intuitive feel for numbers including various uses and meanings, an appreciation for different levels of accuracy needed, and the ability to determine the reasonableness of answers.

- **Mathematics as Reasoning**

  Students should use critical thinking skills in questioning, elaborating, validating, and justifying.

- **Mathematics as Connections**

  Topics within mathematics should be interconnected rather than taught in isolation. Additionally, problems and procedures should be connected to other subject areas and to real-life, relevant situations that are challenging and motivating to the student.

- **Mathematics as Communication**

  Students should be provided opportunities to express their mathematical ideas through speaking, writing, demonstrating, and modeling. (pp. 7-8)

Focus Curriculum, Reduce Breadth

One of the significant issues about U.S. mathematics and science education raised by results from the TIMSS (NCES, 1996) relates to the evidence that the breadth of the typical local curriculum (high number of topics) is so great that students are not developing adequate understanding of core concepts. A strong rationale for national professional standards, and for state standards, is to focus curriculum and instruction on fewer concepts with more depth. Greater focus of curriculum will place emphasis on students gaining deep understanding of the "big ideas" of mathematics and science, and increase coherence and consistency in curriculum across grade levels. *Our expert panel found that state standards can have very important effects in improving the focus of curriculum and reducing excessive breadth and number of topics.* The use of state content standards at the local level can increase focus on core content areas and establish clear expectations for students. It will depend upon how the benchmarks are woven with a unified curriculum that is both conceptually based and applied to real world problems.

For some states, the recent work on standards and frameworks is their first statewide effort to recommend a common basis for curriculum in mathematics and science. If schools and districts respond to

the new state standards, they could have important effects in helping focus curriculum.

- State mathematics standards give a strong, consistent push for greater emphasis on higher-level mathematics, not typically taught in elementary and middle grades previously, such as measurement, geometry, algebra, problem solving, reasoning, and statistics.

- State science standards consistently emphasize to active hands-on student learning and doing of science, which has not typically been found in elementary and middle grades science or in all high school science. State frameworks and standards advocate standards on K–12 scientific inquiry and place emphasis on big ideas and concepts in life, physical, and earth science throughout K–12 science education.

- Possibly the largest area of consistency across state standards and frameworks is the insistence that the expectations in K–12 mathematics and science are the same for all students.

If a state's vision of curriculum and instructional reform were realized, schools would be moving away from ability grouping that restricts the curriculum and materials students have the opportunity to use and learn. Overall, the message of states in recent state standards and frameworks documents is toward setting challenging academic standards that all students should meet, and they typically give schools and districts responsibility for organizing instruction so that students will meet the targets. It is rare for the states to advise local districts, teachers, and administrators on important organizational and pedagogical issues such as reducing tracking and differentiated instructional grouping.

At this juncture in standards implementation, the CCSSO study could not evaluate whether recent state standards and frameworks reduce the excessive breadth in curriculum because there is not yet evidence about how existing curriculum and instruction would be "fit" or "adapted" to the standards. For example, it is unclear from most states' standards or frameworks whether schools would need to reshape, cut back, or expand their curriculum. One of the questions of great interest in the application of standards for all students is: Will the standards alter the school curriculum, how courses are organized, and what and how teachers teach? State documents do not yet show how educators use standards to evaluate local curriculum or secondary course structure. Few provide examples of how to evaluate the changing curriculum against the new standards, although most states do recommend that standards be used by local educators to reevaluate the local curriculum and course structure.

Contributors to Quality of State Standards

- Challenging content and clear expectations
- Communicate links to school improvement
- Strategies toward equity

Our analysis of the subject content of state standards and frameworks showed that at the main standards level, states have generally recommended challenging, rigorous content, and the areas of content are largely consistent with national professional recommendations. The CCSSO/PSA concept mapping analysis of state standards and frameworks provides useful evidence about issues of quality. *Analysis results by state can be viewed in Chapter Five (examples from each state showing how standards and benchmarks are written) and Chapter Three (matrix arraying state documents by the concept mapping elements).*

Challenging Content, Clear Expectations

State mathematics and science standards cover challenging content—Benchmarks need to provide specific expectations of student learning appropriate for grade level.

A major difference we found among the states in our analysis is how mathematics and science standards and frameworks documents are organized and structured and what is included, or not included. In some states, the document is aimed for broad use by state and local policy makers, administrators, parents, as well as educators. The curriculum and instructional implications of the standards are expected to be provided in other documents and materials aimed more specifically at educators. *One result of this more lean, standards-only approach at the state level is that the understandings, explanations, and examples of recommended practice that are found in national professional standards for mathematics and science (NCTM, NRC, AAAS) may not be included in state standards.* The CCSSO expert panel observed that when states take a lean approach to the standards document, it is more difficult for educators and decision makers to use the document as a "bridge," or interpretive tool, between national or state standards and local implementation.

We found differences among state documents in the degree to which state documents carry through with the intent of standards in the "benchmarks" or "indicators" providing more detailed statements of expectations for students regarding what they know and can do with subject content. Standards documents vary widely by state in the level of detail and specificity of the benchmarks for the same standard. The examples from several states, below, show the number of benchmarks for a specific standard, such as Algebra for grades 5–8, varies across states from three to 10 benchmarks.

Example of Content Standards and Benchmarks

SOUTH DAKOTA

Standard: Grades 5–8

Mathematics

Algebra Strand: Students will use the language of algebra to explore, describe, represent, and analyze number expressions and relations that involve variable quantities.

(p. 8)

Benchmarks for this Standard

Students will:

1. Analyze and model properties and interrelationships of algebraic concepts.
2. Apply algebraic concepts to solve a variety of problems.
3. Demonstrate an understanding of the abstract algebraic concepts of variable, number expressions, equality, and inequality.

INDIANA

Standard: Grades 5–8

Mathematics

Develop Explorations of Algebraic Concepts and Processes

(p. 95)

Benchmarks for this Standard

1. Use manipulatives and models to develop algebraic concepts.
2. Understand the concept of variable.
3. Represent points on a line or in a plane using numbers.
4. Write equations to represent problems involving equalities and inequalities.
5. Apply algebraic methods to solve a variety of real world and mathematical problems.
6. Recognize relationships among multiple representations of patterns and functions.
7. Utilize appropriate technology in the investigations of multiple representation of patterns and functions.
8. Explore slopes and intercepts of graphs of linear functions.

MASSACHUSETTS

Mathematics

Algebra (grades 5-8): Students engage in problem solving, communicating, reasoning, and connecting to:

- Understand and apply the concepts of variable, expression, and equation.
- Represent situations and number patterns with tables, graphs, verbal rules, and equations and explore the interrelationships of these representations.
- Analyze tables and graphs to identify properties and relationships.
- Demonstrate an ability to solve linear equations using concrete, informal, and formal methods.
- Describe the strategies used to explore inequalities and nonlinear equations.
- Apply algebraic methods to solve a variety of real-world and theoretical problems.
- Construct expressions or equations that model problems.
- Explore and describe a variety of ways to solve equations, including hands-on activities, trial and error, and numerical analyses.
- Know and apply algebraic procedures for solving equations and inequalities.

(p. 61)

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These examples of state benchmarks show quite different expectations for students, as outlined by the state, and quite different ways of communicating to teachers what is critical to teach and to assess in students' performance in the area of Algebra. One set of benchmarks leaves almost all of the definition and interpretation of Algebra performance to the district, school, or teacher, while other sets of benchmarks quite clearly define at the state level expectations about student performance in Algebra.

Communicate How Standards Link to Improvement

Standards must be substantively rich and provide clear ideas and examples about how teaching and learning would change, as modeled in the national professional standards, if they are to move instruction beyond traditional, fact-driven, and memorization approaches to mathematics and science education.

Substantive Detail

National professional standards documents in mathematics and science focused on a relatively small number of standards that have substantive continuity across grades and provide content detail for grade blocks (e.g., K–4, 5–8, 9–12). The NCTM mathematics standards have about 14 standards per grade block (NCTM, 1989). The NRC science standards have seven standards per block (NRC, 1995). The national standards documents included a rich description of content expectations, giving adequate detail to convey the key constructs and concepts underlying standards.

Standards should lead toward developing teaching strategies, writing curricula, and raising expectations for students.

Appropriately placed verbs clearly signal the level of expectation for student knowledge and performance (e.g., "explain" or "demonstrate" vs. "know" or "understand"). The national documents also explain why these standards are important, and recommend and suggest how standards can be moved into curriculum practice. The national documents in mathematics and science do an excellent job of informing the reader, professional and lay, about the meaning and implications of the standards, and what one would expect to see in classrooms that are working toward standards.

Format, Language

Substantive detail and clarity are only one element of the effectively written, usable standard. Some of the state documents were judged by our panel not to provide high-quality communication of standards. The format and language in which state standards are written can make them more or less meaningful and practical for simply another document that gives a broad outline to a subject area. If a state's document refers to the same standards as national documents and uses the same terms, but does not provide a clear, well-written explanation of the standard or uses verbs that connote low or unclear expectations for students, teachers or administrators in the state may not gain the message of the standards. They may see the "standards" as simply another list of topics that students are expected to learn. If the topics are too broad, teachers might easily attempt to meet them with traditional curricula, materials, or teaching practices, or what is actually taught in classrooms as numeration and number operations or life science, for example, will not be consistent with standards. *See Chapter Three for analysis of how standards are communicated.*

Thus, standards written poorly or incompletely might do little to change or question an existing curriculum that presents the subject as disconnected sets of facts and skills. There is, further, a danger that standards could add more confusion to the curriculum rather than increase the focus. Standards written as lists of recommended topics can miss the central emphasis on learning for understanding, problem solving, and applications to real-world activities emphasized in national professional standards.

Good Examples

Many states have worked hard to incorporate clearly written examples, illustrations, and sample activities. New York, Massachusetts, and Michigan are

examples of states that have moved toward the goal of ensuring that local educators really get the message of what teaching towards standards implies for their own curriculum and practice.

Strategies Toward Equity

State content standards and frameworks documents commit to applying the standards equally to all racial/ethnic, gender, and disability groups. Two major shortcomings were found by our review panel. First, the standards typically outline a comparable curriculum for all students moving through K–12, but the panel did not find good examples of a vision of how current school curriculum and school organization will need to change to reach this goal. Second, with a few exceptions, the review panel does not see standards or criteria that would provide a way to evaluate whether any equity goal had been accomplished.

Equity and inclusion in mathematics and science curriculum and opportunities are typically given as state goals; most states need standards for determining progress.

To reach a goal of applying common content standards to all students, districts and schools need leadership in developing strategies for teaching mathematics and science that can advance equity. For example, instructional practices are needed that allow students from different backgrounds to excel. Recent studies have shown that disadvantaged students that are placed in classrooms offering more intense, varied, and authentic instructional experiences can master more complex, demanding tasks (Knapp and Shields, 1990; Lee, Smith, and Croninger, 1997). Suggestions are needed for districts and schools on how to organize mathematics and science curriculum that does not rely on grouping by ability or prior achievement, since it has been clearly demonstrated that highly differentiated secondary course offerings does most harm in holding back disadvantaged students (Lee, Bryk, and Smith, 1993; Oakes, 1990).

Models for Pedagogy

Ensuring an equity agenda challenges experts. Our review panel agreed that "you need to do something different" so that expectations are consistent for all students and teachers rely on research-based instruction that sustains academic support for peoples of color. "The problem is," one reviewer observed, "that no one knows how to achieve the expectations" the standards establish. *Models of pedagogy should be coupled with models for analyzing data to find where and what kinds of instructional circumstances are obstacles for specific groups of students.* States or districts could show the way on how schools can use disaggregated data and item analyses to understand the unmet cognitive demands of students. In one state, they have pushed equity issues by analyzing test results at the item levels in relation to benchmarks. Districts and schools receive test information in the form of item analyses that demonstrate the specific content areas they should be addressing at each grade.

Many states are either silent on equity issues or they endorse equity goals without substantive support. In general, the standards fail to demonstrate a culturally responsive pedagogy. Such an approach would reflect emerging evidence that cognitively-based instruction connects the content expectations of the curriculum with the personal experiences of learners (Knapp and Shields, 1990). It would also mean ensuring access and opportunity for students who have not been well served by the system to date.

State team representatives to the CCSSO review discussed issues in standards and equity. A difficult task for states is delivering the message that applying standards to all may result in different allocation of resources to schools and different ways of utilizing teaching staff. States that have decided on a narrower, leaner approach to writing standards find it is difficult to address equity issues within the standards document because the implications of standards and the suggested curriculum strategies are purposely absent from the document.

Examples

Delaware, Maine, and New Jersey have developed standards or principles for equity in mathematics and science. Alaska, Massachusetts, Arkansas, and Rhode Island offer strategies and suggestions for organizing mathematics and science curriculum so all students have opportunities to achieve the standards without relying on differentiated tracks or academic programs.

Appendix B gives examples from Alaska, Delaware, and Maine.

Teaching, Assessment, Program Standards in Few States

States all recommend a set of "content standards," but only a few place emphasis on teaching standards, assessment standards, and program or system standards.

The national professional standards documents emphasize several kinds of standards for improving mathematics and science education. The NRC National Science Education Standards (1995) incorporated five types of standards in one document (content, teaching, assessment, program, and system). NCTM has published three separate volumes on curriculum and evaluation standards (1989), teaching standards (1991), and assessment standards (1995). Some states do address teaching strategies and instructional practices in relation to subject content within the same document—such as Alaska, Maine, New Jersey, Michigan, and Kentucky. Others have produced separate, but related, documents on teaching with examples of instructional practices—such as Delaware, Montana, Rhode Island, and Utah.

Teaching Standards

The separation of teaching examples into a supplement is a practical solution when the standards were designed for multiple audiences. But there are drawbacks for implementation. By divorcing suggestions for improving practice from the standards, critical changes in pedagogical strategies and the connection to subject matter content may be missed by teachers or assessment developers. However, the location of examples, models, or exemplars for practice may not be as critical as whether or not states provide leadership for schools in this area at all. The expert review panel emphasized that applying and using standards or frameworks will be a developmental and learning process for educators. For standards to produce change in teaching and learning, classroom educators are going to need to be able to compare their current teaching strategies and curriculum content with strategies and content that are being recommended. A review of state standards and frameworks in 1996 found some of the teaching and classroom examples to be too brief or hard to use for teachers (Humphrey and Shields, 1996).

Assessment

Many of the state standards and frameworks refer to plans for state standards to be linked to new methods of student assessment. Some of the state standards or frameworks outline sample assessment exercises and suggest criteria for developing good assessments for classroom use or accountability purposes. State documents that can be consulted for examples of assessments and assessment standards are Alaska, Delaware, Maine, and New Jersey. Also, a suggested set of "criteria for alignment of curricular expectations and students assessments" is presented in a new monograph by Norman Webb published jointly by CCSSO and the National Institute for Science Education (Webb, 1997).

Measurable Standards

The CCSSO expert review panel examined the degree to which state standards and frameworks provided "measurable" standards, benchmarks, or performance standards. The reviewers addressed two questions: were the standards written with sufficient specificity to allow an assessment developer to determine what knowledge and performance is expected of students at a given grade level? Could the standards be used to develop

assessment specifications or exercises, either for state assessments or for classroom assessment? The panel reviews produced the following results on the "measurability" of the state standards among the 16 states reviewed:

- **Measurable: six states' standards**. Almost half of the 16 states had sufficiently specific and clear expectations for performance in mathematics and science, in the view of the panel. The states were: Alaska, Colorado, Maine, New Jersey, Kentucky, and Missouri.

- **Partially Measurable: seven states' standards**. According to our panel, four of 16 states have standards or benchmarks statements that are sufficiently specific about subject content, but the expected level of performance is not evident.

Three states had measurable standards in mathematics or science, but not both.

- **Not measurable: three states' standards**. The panel viewed three states as needing further work on developing standards that could be used in writing and developing assessments.

Implementation of State Standards and Frameworks

- Strategies for Demonstrating Curriculum Change
- Support for Implementation
- Align Assessment
- Performance Standards
- Professional Development Plan

Strategies for Curriculum Change

Two-thirds of states provide some curriculum examples, classroom activities, or vignettes to communicate how content standards can be applied in school curriculum.

The expert review panel found that the process of development of standards and frameworks has generally resulted in rethinking and restating the priorities, organization and sequence of mathematics and science subject content across the grades. One strategy for presenting and communicating standards in a state is to produce a shorter, more lean set of standards statements, e.g., in a 10- to 15-page document. Although such documents may be useful as summary statements that are more easily communicated to a variety of audiences, the expert panel did not find that they were necessarily more understandable or useful to primary intended audiences. Panelists did not find brevity was an advantage in making the standards accessible and understood by local curriculum specialists and teachers.

A state list of expected student learning targets for each grade or grade cluster may help teachers by showing them *what* the standards include and *where* mathematics or science is to be headed in the state, but the standards are not likely to help show them *how curriculum and instruction needs to change* from current practice to the practices envisioned by the standards. Content standards are not designed to provide a different or new set of content topics or to provide more difficult academic content. Rather, the goal of standards setting is to recommend an updated, challenging, focused curriculum and high cognitive expectations that are applicable to all students.

Our concept mapping analysis of frameworks and standards showed that two-thirds of states completing new state documents (24 of 34) had example curriculum, activities or vignettes *(see state-by-state matrix in Chapter Four.)*

- Vignettes are included in 14 of the states' mathematics or science standards or frameworks (of 34 states completed since 1994). Vignettes are intended to illustrate the standards applied in classroom curriculum and instruction.

- Curriculum examples, activities, or tasks are included in 22 states' documents (of 34), and generally show the kind of work that students would be doing with use of standards in developing curriculum.

To use the standards, educators can expect to have available clear and understandable explanations, examples, ideas, and sample activities. In many of the state reviews, panelists found the quality of communication of standards could be significantly improved. Examples of states that have innovative strategies and methods of communicating standards are: Alaska, Delaware, Indiana (mathematics), Massachusetts, Maine, Michigan, New Jersey (mathematics), Rhode Island, and Vermont.

Appendix D gives examples from Alaska, Delaware, Michigan, and Rhode Island.

Extended Support for Standards Implementation

State education leaders see long-term needs for support of standards with schools. States vary widely in strategies for implementation of standards or frameworks, and how they will be used with schools and educators. Some states are moving into the "implementation phase" of their work with standards and frameworks.

Interviews we conducted with state mathematics and science specialists in 1996 provide some basic information about state efforts to disseminate state standards and frameworks documents and strategies for working with local educators to implement them. *Chapter Five contains a state-by-state summary of dissemination and implementation efforts.*

The states participating in CCSSO's qualitative review process were getting ready to move into an implementation phase of their work. Many states were moving their draft state standards toward final approval. The state representatives benefited from sharing implementation strategies and approaches, *States anticipated a number of challenges in putting together several pieces of a standards "system,"* such as:

- how to work with state assessments;

- approaches to professional development beyond a basic orientation to the standards;

- using state documents for modeling curriculum and instruction and for evaluating local curriculum;

- strategies for developing "performance standards" to match content standards; and

- how to organize local groups of educators to examine how the state standards for mathematics and science education can be central to moving a reform agenda.

State staff expressed a need for expanded and extended state support for implementation of standards. They do not see standards being easily adopted by districts or integrated into curriculum without specific assistance from the state level or through projects supported by federal agencies or others. Another threat to chances of implementation of standards is reduction and reassignment of state and local specialists in mathematics and science education. Expertise in teaching these subjects is critical for leading standards efforts.

The results of our interviews with state mathematics and science specialists about state strategies and plans for implementation of standards or frameworks showed that most states reported professional development workshops or conferences

as a primary strategy. Many of the states are holding sessions with districts on writing curriculum. Regional networks of schools and teachers have been formed within states, and almost half the states are using Internet Web sites to provide standards information. At the state level, work with teacher certification standards and state assessment programs were frequently identified as state implementation strategies.

Align Standards with Assessments

The content standards recommended by states call for change in methods of assessing learning; a majority of states do not yet have state assessments that align with current standards.

States reviewed by the CCSSO panel did have *plans* for moving state assessment programs and local assessments toward multiple-method assessments that would be consistent with the recommended standards for student subject knowledge and skills. A majority of the 16 states participating in our standards review reported slow progress toward authentic mathematic and science assessment programs. Interviews with state mathematics and science specialists in almost all states confirm this finding about the status of assessment systems. The new federal Title I legislation requires that assessment systems that adequately measure yearly progress toward state content standards be in place by 2001. It is now unclear, however, whether this will be a strong policy lever for new assessment approaches.

In some states the priority on state assessments that serve the purpose of accountability and reporting has held back change toward assessments that would be more consistent with mathematics and science curriculum reforms. Continuation of strong support for high standards in states will mean continued support for state assessment programs for purposes of accountability. If the standards are read closely, they should move assessment programs away from dependence on only multiple choice items, which provide statistical reliability but typically limited coverage of challenging mathematics and science standards. Many states are planning multi-method assessments that include: writing, open-ended and constructed response items, hands-on performance exercises, and enhanced multiple choice items. For further discussion of alignment issues and criteria please see a new joint publication from CCSSO and the National Institute for Science Education (Webb, 1997).

Our interviews with state mathematics and science specialists about the relationship between new state standards or frameworks and state student assessment programs in mathematics and science show the following state picture. We asked the question "Are the state assessments based on the standards/frameworks?" *Results are reported by state in Chapter Two.*

- Of 46 states with mathematics standards in place, 23 states have a state mathematics assessment program based on standards. The other states have plans for new assessments or they are in development as of 1996.

- Of 46 states with science standards in place, 16 have a state science assessment program based on standards. Twenty of 46 states have plans for a new science assessment or are in the process of development as of 1996.

The direction of state assessment systems are still emerging, leaving most states in a position of using "transitional" versions of norm-referenced tests or earlier state tests as they pilot new approaches. States also present suggestions for classroom assessment using alternative assessment strategies—portfolios, performance tasks, hands-on exercises, and various forms of open-ended testing. *State-by-state information on assessments included in state standards and frameworks is reported in Chapter Three.*

Dissemination and professional development with new standards and assessments is a particular challenge in a period of down-sizing and budget restrictions. Many states turn to regional systems that rely on expert teachers to lead colleagues through the change process. Cross-state alliances through CCSSO and the New Standards are resources for many states during this transition.

Performance Standards or Levels in Development

Performance standards, or levels, are needed to link standards for student learning to new assessments.

States use the term "performance standards" in two different ways—(a) as benchmarks or indicators, i.e., more detailed expectations under the content standards, and (b) as levels of expected performance on student assessments. One goal of the CCSSO study was to analyze the connection between content standards in mathematics and science, performance standards that define the level of expected student knowledge and skills, and assessments that reflect the performance standards. The analysis of these connections is complex because of the varying state definitions of these concepts. For example, our review of state documents showed that what some states call "performance standards" may be hard to distinguish from "content standards" in another state. Using an open-ended definition of performance standards, CCSSO interviews with state specialists showed that 24 states (of 50) reported having performance standards for mathematics or science as of 1996 with this the total including both applications of performance standards, as described above. *See Chapter Two for state-by-state responses.*

Performance standards as recommended levels of student performance or achievement for a specific content area and grade are typically written some time after the completion of the main state standards or frameworks document, and often they are written in conjunction with scoring and reporting of state assessments. CCSSO's fall 1996 survey of state assessment directors showed that 14 states had set performance levels with a state mathematics assessment with more than two levels (e.g., proficient, partially proficient, advanced) that are used in reporting student assessment results (Bond, et al., 1997).

Professional Development Plan for States

States are likely to need long-term plans for professional development and pre-service education with teachers and administrators, and funding from states and other sources to continue to progress with standards.

The concept mapping analysis of 34 state standards and frameworks revealed that 13 of these states directly address professional development or teacher education in their state document *(see Chapter Three)*. Some excellent examples of state strategies were identified in the qualitative review.

- Kentucky has regional educator networks and expert specialists that work with teachers and administrators on units of study, and the state focuses significant professional development effort on teachers' use of portfolio assessment.

- Delaware has implemented a module-based approach to professional development and curriculum reform for elementary science, and the state established a coalition of nine local districts and schools using the approach that recently was awarded a five-year grant from NSF.

- Maine has extensive plans for developing skills and knowledge of teachers using the state framework—vignettes, classroom examples and model lessons are aimed at teachers using the framework. Maine also included professional standards for pre-service and practicing teachers in the state framework. *(See Appendix C.)*

- In Texas, the science standards' writers will become trainers of teams from districts to implement the standards, and a summer science institute is being established.

Chapter Two

State Mathematics and Science Standards, Frameworks, and Student Assessments: Status of 50 States

Many states are working toward systemic education change that includes development and use of challenging standards for student learning in core academic subjects and implementation of student assessments that are based on the standards. The Council has identified the status of key components of this model for change in mathematics and science education in each state as of the end of 1996.

The information in the following table was reported to CCSSO by state mathematics and science specialists. The table covers three key areas of current state activities related to standards: content standards and curriculum frameworks, performance standards, and state assessment based on standards.

State Content Standards and Curriculum Frameworks

For the current CCSSO study of state standards and frameworks, CCSSO worked with states and our study expert panel to arrive at common definitions of key concepts for analysis. We have employed the following definitions of standards and frameworks in reporting their status by state.

Content standards: specify the content knowledge and skills all students will know and be able to do upon completing particular grades or courses in K–12 education; the content standards state clearly the knowledge and skills to be learned, and at what developmental level content is to be presented. In some states, content standards are a separate state document; in others, they are published in a curriculum framework.

Curriculum framework: a document published by a state education agency or state board of education that generally includes desired subject content or standards for a core academic subject in K–12 education, and written by a team of content experts, state agency personnel, and local educators. A state framework often serves as a bridge between national professional standards and local curriculum and instructional strategies, and may address areas of pedagogy, classroom examples and vignettes, strategies toward equity, and important education policies and school conditions. The framework document may also refer educators to other materials and resources to support local efforts.

Mathematics: By the end of 1996, 46 states plus three other jurisdictions (DC, DoDEA, and VI) had completed a state content standards or curriculum framework document for K–12 mathematics education.

Science: By the end of 1996, the same 46 states plus two other jurisdictions (DC, VI) had completed a state content standards or curriculum framework document for K–12 science education.

These totals include states with an adopted state document plus those with a draft review document. The state-by-state information in the table below provides the document titles, date, and whether a state has separate standards or framework documents for mathematics and science, or a combined document.

Thirty-two of the 46 states completed their standards or frameworks document between the end of 1994 and the end of 1996. Almost all of the remaining 14 states completed their standards or frameworks from 1990 to 1994.

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Performance Standards

Performance standards specify how good is "good enough"—usually in conjunction with a method of assessment—and gauge the degree to which content standards have been attained by individuals or groups, indicating the nature of the evidence and the quality of student performance on agreed upon tasks or measurement instruments.

- Specialists in 24 states reported their state had completed development of "performance standards" for mathematics or science as of 1996.

This total is based on an open-ended definition of "performance standards" as: (a) "benchmarks" or "indicators," i.e., more detailed expectations under the content standards, or (b) levels of expected performance or achievement on student assessments.

State Assessment Based on State Standards

A state assessment based on state standards is defined as a statewide student assessment in mathematics or science given at one or more grade levels that has been designed and constructed by the state to assess student learning according to state content and/or performance standards.

- Of 46 states with science standards in place, specialists in 16 states report that a state science assessment is based on the recently completed standards. Twenty of the remaining states are developing or have plans for a new science assessment.

- Of 46 states with mathematics standards in place, specialists in 23 states report that a state mathematics assessment is based on the recently completed standards. The remaining 23 states are developing or have plans for new assessments.

CCSSO asked state mathematics and science specialists to indicate the relationship of state content standards or frameworks (shown in the table) and state student assessment programs in mathematics and science (i.e., "Is there a state assessment based on the standards or framework?"). Some current state assessment programs in mathematics and science are not viewed by the state as based on the standards and are not reported here. They may be called "interim" or transition assessments. A 1996 Council report contains a listing of all state assessment programs by subject, grade, and type of assessment (CCSSO/State Education Assessment Center, *Key State Education Policies for K–12 Education*, 1996).

Note: This chapter is available on the CCSSO Web page (www.ccsso.org).

Status of Standards and Assessment Development in the States

State	Content Standards or Curriculum Framework Document	*Performance* Standards (State Term, Document)	State Assessment Based on State Standards
AL	*Alabama Course of Study: Mathematics* (1989) [rev. 1997]	Student outcomes in *Course of Study*	Stanford 9
	Alabama Course of Study: Science (1995)	Same as above	Stanford 9
AK	*Alaska Mathematics and Science Framework* (1996)	Performance Standards in development	To develop after performance standards complete
AR	*The Arkansas Mathematics Curriculum Framework* (1994 Edition)	–	Comp. Testing and Assess. Prog. (pilot, 1996) Stanford 9 @ grades 4, 7, 10
	The Arkansas Science Curriculum Framework (1994 Edition)	–	ACTAP (pilot, 1996) Stanford 9 @ grades 4, 7, 10
AZ	*Arizona Academic Standards Mathematics* (1996)	–	In development
	Arizona Academic Standards Science (1990)	–	In development
CA	*Mathematics Framework for California Public Schools, K–12* (1992); *Content Standards in Mathematics* (draft, 1996)	Performance Standards in development, 1998	Statewide assessment after standards in place
	Science Framework for California Public Schools, K–Grade 12 (1990)	In development, 2003	Same as above
CO	*Colorado Model Content Standards for Mathematics* (1995)	*Colorado Performance Levels* (draft, 1996)	In development
	Colorado Model Content Standards for Science (1995)	Same as above	Same as above
CT	*A Guide to Curriculum Development in Mathematics* (1981) [rev. 1997] *Assessment in Mathematics* (1996)	State Standards in *Handbook for Improving Instruction & Assess.* (1996)	CT Academic Performance Test (CAPT) Math
	A Guide to Curriculum Development in Science (1991) [rev. 1997]	Same as above	CAPT Science
DC	*Mathematics, Science, and Technology Curriculum Frameworks, Grades K–12* (1995)	Performance Indicators in Frameworks	Under development; currently using CTBS
DE	*Mathematics Curriculum Framework: Content Standards, Volumes I and II* (1995)	Performance Standards in development	Developing
	Science Curriculum Framework: Content Standards, Volumes I and II (1995); *Classroom Performance Models, Vol. III* (August 1996)	Same as above	Developing
DoDEA	*Mathematics Standards and Expectancies* (1994)	Grade Level Expectancies	Preparing Guidelines
	Science Content Standards (Draft in progress)	Performance Standards in progress	–
FL	*Florida Mathematics Curriculum Frameworks* (1996)	–	–
	Science for All Students: The Florida PreK–12 Science Curriculum Framework (1994)	–	–
GA	*Quality Core Curriculum K–12* (1989) [includes math and science; rev. 1997]	–	Curriculum Based Assessment (1992)
Guam	No current information	–	–
HI	*Hawaii Content and Performance Standards*	*HI Commission on Performance Standards* (1994)	To be developed
IA	*A Guide to Curriculum Development in Math* (1987) *and Science* (1991) (not standards)	None	No state assessments
ID	*Idaho K–12 Mathematics Content Guide and Framework* (1994)	Performance Objectives in Framework	–
	Idaho K–12 Science Content Guide and Framework (1994)	–	–

Note: **"–" = No state document or assessment reported**

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State	Content Standards or Curriculum Framework Document	*Performance* Standards (State Term, Document)	State Assessment Based on State Standards
IL	*Academic Standards in Learning Areas* (draft, 1996), [complete 1997]	Learning Benchmarks in *Academic Standards*	Assessment; expected 1999
IN	*Indiana High School Math Competencies* (1995), *Mathematics Proficiency Guide* (draft, 1996)	Proficiencies in *Proficiency Guide*	IN Statewide Test of Educational Proficiency Plus
	Indiana High School Science Competencies (1995), *Key Elements of the Science Proficiency Guide* (1993)	Same as above	None
KS	*Kansas Math Curriculum Standards* (1993)	Standards of Excellence in all state assessment reports	KS Math Assessment (1991)
	Kansas Curriculum Standards for Science (1995)	–	KS Science Test, developing 1997
KY	*Transformations: Kentucky's Curriculum Framework* (Revised 1995) [Mathematics, Science, other subjects]	Proficiency Levels in *Core Content for Math and Science Assessment* (1996)	KY Results and Information Systems (1991) [annual revisions]
LA	*Louisiana Mathematics Framework* (1995); Supplement: Grade-Level Activities	Performance Standards in development (1997)	Assessment under development
	Louisiana Science Framework (1996)	Same as above	Same as above
MA	*The MA Mathematics Curriculum Framework: Achieving Mathematical Power* (1995)	Performance standards in development, Fall 1996	Pilot assessment, Spring 1997
	The MA Science and Technology Curriculum Framework: Owning the Questions Through Science and Technology Education (1995)	Same as above	Same as above
MD	*Mathematics: A Maryland Curricular Framework* (1985); *High School Assessment Mathematics Core Learning Goals* (1996)	Learning Outcomes *(core subjects)* for *MD School Performance Assessment Program* (1990)	MD School Performance Assessment Program (1991)
	Science: A Maryland Curricular Framework (1985); *High School Assessment Science Core Learning Goals* (1996)	Same as above	Same as above
ME	*Maine Curriculum Framework for Mathematics and Science*, (1995); *Maine's Learning Results* (core subjects) (draft, 1996)	Performance Indicators in *Framework*	ME Education Assessment (1987)
MI	*Michigan Curriculum Framework* (1996); *Michigan Mathematics Content Strands, Standards, & Benchmarks* (1996)	Model Benchmarks in *Frameworks and Standards*	–
	Science Education Guide Book (1996)	Same as above	–
MN	*Mathematics Curriculum Frameworks*, draft [final, 1997]	–	–
	Science Curriculum Frameworks, draft [final, 1997]	–	–
MO	*Math Curriculum Frameworks* (1996)	*Show Me Standards* (1996)	New statewide test, Spring 1997
	Science Curriculum Frameworks (1996)	Same as above	Same as above
MS	*Mississippi Mathematics Curriculum Structure* (1995); *Mathematics Process Guide* (1995)	–	ITBS Math Battery and Perform. Assess. (Gr. 4–9); Algebra I test (1996–97)
	Mississippi Science Framework (1996)	–	Biology I test (1997–98)
MT	*Mathematics Curriculum Framework* (1996)	–	–
NC	*Standard Course of Study, Competency-based Curriculum: Teacher Handbook Math K–12* (1994)	Objectives in *Course of Study*	State End-of-Grade and End-of-Course tests
	Standard Course of Study, Competency-based Curriculum: Teacher Handbook Science K–12 (1994)	Same as above	Same as above
ND	*North Dakota Curriculum Frameworks, Math* (1993) [rev. 1997]	In development, Fall 1997	–
	North Dakota Curriculum Frameworks, Science (1993) [rev. 1997]	In development, Fall 1999	–
NE	Math and science *Frameworks for Nebraska Schools* (1994); Addendum (1995)	None	None

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State	Content Standards or Curriculum Framework Document	*Performance* Standards (State Term, Document)	State Assessment Based on State Standards
NH	*K–12 Mathematics Curriculum Framework* (1995) (unofficial); Addendum: Instructional Materials (unofficial)	Proficiency Standards in *Framework*	NH Educational Improvement and Assessment Program Gr. 3 (1994); Gr. 6, 10 (1996)
	K–12 Science Curriculum Framework (1995); Addendum: Instructional Materials (unofficial)	Same as above	NH Educational Improvement and Assessment Program (Gr. 6, 10)
NJ	*Core Curriculum Content Standards* (1996); *Mathematics Framework* (1995) (unofficial) *Core Learning Goals* (1996)	–	Math Assessment, Gr. 4, 8 (pilot, 1997) Science Assessment, Gr. 4, 8, 11 (pilot, 1997–98)
NM	*Mathematics and Science Content Standards with Benchmarks* (1996)	Performance Standards in *Technical Assistance Document* (1996)	In development
NV	*Math Course of Study* (1994) [rev. 1999]	Performance Standards (1999) NV Proficiency Test, Gr. 11	Terra Nova, Gr. 4, 8;
	Science K–12 Course of Study (developing 1998)	(1998)	No mandate (pilot, CRT, 1999)
NY	*Learning Standards for Math, Science, and Technology* [final, 1997]	Performance Indicators in *Standards*	Math, Gr. 4, 8, HS (1999); Science being discussed
OH	*Model Competency Based Mathematics Program* (1990)	*Learning Outcomes*	Ohio Proficiency Test (in place)
	Model Competency Based Science Program (1994)	Same as above	Developing
OK	*Priority Academic Student Skills* (1993) [rev. 1997]	–	Oklahoma Testing Program, Math & Science (1995)
OR	*OR Common Curriculum Goals, Content Standards and Benchmarks* (1996)	Performance Standards: Gr. 3, 5, 8, 10 (1996)	Oregon Statewide Assessment: Math
PA	*Mathematics Curriculum Framework* (1996)	–	–
	Science and Technology Framework (1995)		
PR	No current information	–	–
RI	*Mathematics Framework K–12: Intellectual Power for All Students* (1995)	In development (1998)	MAT, with performance assessments, pilot (1996) Gr. 4, 8, 10
	Science Framework: Science Literacy for All Students (1995)	None	Developing with new Standards Assessment—Science
SC	*SC Mathematics Framework* (1993)	Academic Standards in *Framework*	Pilot (1997)
	SC Science Framework (1995)	Same as above	Pilot (1997)
SD	*SD Mathematics Standards* (1996)	None	–
	SD Science Standards (1996)	None	–
TN	*TN Comprehensive Curriculum Guide, K–8* (1992) [rev. 1997]; *Mathematics Curriculum Framework, 9–12* (1992)	None	TN Competency Testing Program, Gr. 9 (1996), Course Tests: Alg. I, II, Geometry, Pre-Alg.)
	Science Framework, K–12 (1995)	None	–
TX	*Mathematics: Texas Essential Knowledge and Skills* (1997)	None	Math Assessment, Gr. 4 (pilot)
	Science: Texas Essential Knowledge and Skills (1997)	None	Same as above
UT	*Mathematics Core Curriculum*, K–4 (1993), 5–7 (1993), 7–12 (1995)	In *Math Core Curriculum*	End of Level Test (1997 implementation)
	Science Core Curriculum, K–6 (1994), 7–12 (1995)	In *Science Core Curriculum*	End of Level Test, K–6 (1996) 7–12 (developing 1998)
VA	*Mathematics Standards of Learning for VA Public Schools* (1995)	–	Redesigned assessment (implemented 1998)
	Science Standards of Learning for VA Public Schools (1995)	–	Same as above

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Status of Standards and Assessment Development (cont'd)

State	Content Standards or Curriculum Framework Document	*Performance* Standards (State Term, Document)	State Assessment Based on State Standards
VI	*Mathematics Curriculum Framework* (1995)	–	–
	Science Curriculum Guide (1995)	–	–
VT	*Vermont's Framework of Standards and Learning Opportunities* (1996)	–	Comprehensive assessment system phased in next 10 years
WA	*Essential Academic Learning Requirements: Reading, Writing, Communication, Mathematics (1996)*	Proficiency Standards on Math Assessment	Developing Math Assessments Gr. 4,7,10 (1999)
	Essential Academic Learning Requirements: Science, Social Studies, Arts, Health and Fitness (1996)	–	–
WI	*Mathematics Academic Standards*, Draft [Final 1997]	Proficiency Standards	–
	Science Academic Standards, Draft [Final 1997]	Same as above	–
WV	*Instructional Goals and Objectives for Mathematics* (1996)	Objectives in *Instructional Goals*	Stanford 9, Gr. 1-11
	Instructional Goals and Objectives for Science (1996)	Same as above	Stanford 9, Gr. 3-11
WY	*Standards of Excellence for Math Education* (1990)	–	–
	Standards of Excellence for Science Education (1990)	–	–

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Chapter Three

Similarities and Differences Among State Mathematics and Science Documents: A Graphic Comparison

Many educators and decision-makers would like to have a guide to the similarities and differences in how states have written and produced state documents on mathematics and science.

Such a guide would allow state and local curriculum specialists and education decision-makers to identify which state documents address which topics of interest, such as sources of information, benchmarks, assessment, professional development, curriculum vignettes or sample classroom activities, or recommendations on curriculum materials or educational technology.

In this chapter we present results from our 1996 concept mapping analysis of new state standards and frameworks in mathematics and science. Included in the analysis were documents completed by 32 states, DC, and DoDEA, and all completed between 1994 and mid-1996. The results of the concept mapping analysis are arrayed in the following "cross-state map" using 15 elements analyzed across states.

- Cross-State Map 1: Elements 1–8
- Cross-State Map 2: Elements 9–15

The concept mapping analysis was based on a set of elements defined by CCSSO and the study expert advisory panel. The elements were selected according to a review of the current "state of the art" in developing such documents, and from a consensus of panelists on the uses of state frameworks and standards documents for intended audiences, including policy makers, educators, administrators, and the public.

Analysis of each state document was completed by research staff. The concept mapping analysis for each state was guided and structured by a set of "Definitions of Categories and Concepts" (Appendix E). The research staff had backgrounds in mathematics and science education, and training was provided in use of the definitions and mapping procedures.

Summary of Findings

Following are paragraphs defining each element in our analysis of state frameworks and standards documents, as well as aggregate totals of the element across states. *See Chapter Five for examples of standards and benchmarks from each document in the analysis.*

State: Documents were reviewed from 32 states, DC, and DoDEA that completed state standards and frameworks from 1994 through 1996. Titles, descriptions, and examples from these documents are provided in Chapters Two and Three.

Date/Status: The year the document was completed, and whether it is "adopted" by state board, "complete" or final (not addressed by state board), or in review "draft" status at the end of 1996.

No. of pages: Number of pages in the document. This number does not include any supplemental or related documents. The number of pages in state standards and framework documents is included only for descriptive purposes. The state documents vary from less than 20 pages to 300 pages.

Funding: Sources of funding that were mentioned in the document as supporting development and writing. Nineteen states (of 34 reviewed) had support for development from federal sources—the Statewide Systemic Initiatives (SSI) from the National Science Foundation, the Eisenhower Math-Science Frameworks Development grants (IKE) from the U.S. Department of Education, or state funds from federal programs under Title II or Title IV.

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Related Documents: Other state-produced documents that provide further information on standards, elaboration, examples, instructional activities, assessments, curriculum plans, or models in support of the main standards of framework document. Twenty-two of 34 states described a related document.

Sources of Information: Publications from national professional organizations, other states, or the same state that were directly referenced as a source for the state standards or framework.

The National professional standards documents are: Mathematics education—NCTM, National of Teachers of Mathematics, Curriculum and Evaluation Standards for School Mathematics (1989); Science education—AAAS, Benchmarks for Science Literacy (1993); NRC, National Research Council, National Standards for Science Education (1995).

Development: Indicates whether the process or steps in development of the standards or framework document are described in the document.

Content Standards: The number of main or primary content standards for what students in mathematics or science in the state should know and be able to do. The grade span covered by the standards is listed. The state's definition and term for content standards is outlined in the state-by-state summaries. Twenty-five states have content standards that cover grades K–12 (of 34), while nine states have separate standards by grade, grade cluster, or secondary course.

Benchmarks or Indicators: The number of statements under each state content standard that provide more detailed recommendations on what students are expected to know and be able to do. The method of organizing the benchmarks/indicators per standard is given, often by grade cluster, e.g., K–4, 5–8, 9–12. Twenty-eight states wrote the benchmarks or indicators by grade cluster (of 34), and six states wrote them by grade or course.

Communication: Methods by which the state tries to communicate, explain, or provide understanding about the standards and their application.

- "Vignettes" are included in 14 of the states' mathematics or science standards or frameworks (of 34 states). Vignettes are intended to illustrate the standards applied in classroom curriculum and instruction.

- Curriculum "examples," "activities," or "tasks" are included in 22 state documents (of 34). They generally show the kind of work that students would be doing when standards are used in developing curriculum. These totals do not include vignettes, examples, activities, or tasks that may be included in supplemental or related state documents.

Equity: How, and if, the state document addresses the development and implementation of curriculum that will increase inclusion and opportunity in mathematics and science learning for all students, regardless of race/ethnicity, gender, or disability.

Pedagogy: Extent to which approaches to teaching and learning are presented in the state document. Some state frameworks or standards give examples of classroom activities, standards for teaching, or student work in the classroom that would exemplify the benchmarks or indicators for standards.

Assessment: States moving toward systemic reform of math and science education will be working to link state assessment programs and classroom assessments (given by teachers) to state and local content standards. Our analysis found that of 34 states' documents analyzed 18 states explicitly discussed approaches or examples of classroom assessment, and 11 states explicitly discussed assessments for external accountability such as state assessment programs.

Professional Development: Extent to state document discusses approaches to professional development with science or mathematics teachers linked to standards, or recommendations are presented for improving professional development. Thirteen states' documents (of 34) do contain some discussion, reference, or recommendations on professional development.

Use of Technology: Extent to which state document discusses approaches to use of educational technology in improving science or mathematics education in relation to standards, or presents recommendations for improving use of technology. Twenty-five states' documents (of 34) discuss or recommend approaches to use of technology.

Materials and Texts: Extent to which state document discusses approaches the need for educational materials, equipment, laboratory supplies, and textbooks for improving science or mathematics education in relation to standards, or presents recommendations for improving access and availability of materials and texts. Fifteen states' documents (of 34) discuss or recommend improvements in and use of materials and texts.

Note: The 16 states not represented in the cross-state map either completed their frameworks or standards prior to 1994 or did not submit a framework or standards document to CCSSO for review. Some states continue to develop or revise their standards and are publishing new documents. This map is current as of the end of 1996; CCSSO will continue to monitor and report activities of the states.

Note: This chapter is available on the CCSSO Web page (www.ccsso.org).

Cross-State Map of Mathematics and Science Documents

Elements One Through Eight

Alabama to New Jersey

STATE (Subject)	Date/ Status	No. of Pages	Funding	Related Documents	Sources of Information	Development	Content Standards	Benchmarks Indicators
AL (S)	1995 Adopted	150	None indicated	*Supplement*	National documents	Briefly explained	10 science by grade K-8, course 9-12	5 per standard by grade/course
AK (M,S)	1996 Final	258	IKE grant	*Ref. Kit, Resource Notebook*	NCTM, NSTA, NRC, AAAS, Others	Explained	5 math, 4 science K-12	4-8 per standard by age cluster
CO (M,S)	1995 Adopted	25M, 33S	State	*Model Content Standards*	NCTM, AAAS, NRC	Described in earlier drafts	6 math, 6 science by K-12	4-7 per standard by grade cluster
DoDEA (M	1996 Adopted	106	None indicated	None indicated	National documents	Not described	10-14 by grade K-8, course 9-12	5 per standard by grade cluster/course
DE (M,S)	1996 (M) Adopted 1995 (S) Adopted	98M, 84S	SSI, IKE grant, private in-state	*Vol. II* (M,S) *Performance Models Vol. III* (S)	National documents	Explained in science	10 math, 8 science K-12	3-12 per standard by grade cluster
DC (M,S	1996 Adopted	67	SSI, IKE grant	None indicated	National documents	Not described	7 math, 6 science gr. 3, 5, 8, 11	4-6 per standard
KY (M,S	1996 Draft		Not indicated	*Transformations* (1993)	*Transformations*	Not described	4 math, 3 science K-12	5-10 per standard by grade cluster
IL (M,S)	1996 Draft	25M, 25S	Not indicated	None indicated	NRC, NCTM	Not described	5 math, 3 science K-12	1-4 per standard by grade cluster
IN (M)	1995, 1996 Final	300	Title II	*HS Math Comp.* (1995)	NCTM	Steps described	11 math K-12	7 per standard by grade cluster
KS (M,S)	1995 Draft	41	Not indicated	None indicated	National documents NCTM	Not explained	5 for all grades	1-6 per standard by grade cluster
LA (M,S)	1996 (M) Adopted 1996 (S) Draft	44M, 44S	SSI, IKE grant, state matching	Supplemental materials	NCTM, NRC, AAAS	Steps explained	6 math, 5 science K-12	3-15 per standard by grade cluster
MA (M,S)	1996 (M) Adopted 1995 (S) Adopted	111M, 126S	SSI, IKE grant	None indicated	National documents	Steps explained	4 math, 4 science K-12	4-8 math, 8-12 science per standard by grade cluster
ME (M,S)	1995 Adopted	16S	SSI, IKE grant	*Math Process Guide*	NCTM, AAAS, NRC	Steps explained	9 math, 9 science K-12	5-20 per standard by grade cluster
MI (M,S)	1996 Adopted	75M 12S	IKE grant	*Guidebook* (S); *Framework* (M)	National documents	Process explained	15 math, 15 science K-12	5-7 per standard by grade cluster
MS (M,S)	1994 (M) Adopted 1996 (S) Adopted	86M, 219S	Not indicated	*Math Process Guide*	NCTM, National Goals, NRC, AAAS, NSTA	Process explained	6 math, 4 science by grade K-8, course 9-12	4-5 math, 15 science per standard by grade/course
MO (M,S)	1996 (M) Draft 1996 (S) Draft	95M 103S	Not indicated	*Show-Me Standards*	National documents	Process explained	10 math, 8 science K-12	4-5 per standard by grade cluster
NJ (M,S)	1995 Adopted	39M, 21S	IKE grant	*Instr. Guide, Math Framewk* (1994)	NCTM, AAAS, NRC	Steps explained	18 math, 13 science K-12	4-8 per standard by grade cluster

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Elements NineThrough Fifteen

Alabama to New Jersey

STATE (subject)	Communication	Equity	Pedagogy	Assessment	Professional Development	Use of Technology	Materials and Texts
AL (S)	No examples	Brief mention	Introductory Sections	Brief mention	Not addressed	Application Standards	Not addressed
AK (M,S)	Vignettes Assessment Activities	Standards, examples, bibliography	Encourages practices	Classroom	Context Chart	Discussed Appendix	Not addressed
CO (M,S)	Math examples; Science skill lists	In vision statement (and ref. math)	Addressed in math only	Examples in math	Not addressed	Discussed in both	Not addressed
DoDEA (M)	Tasks Examples	Briefly discussed	Briefly discussed	Not discussed	Not discussed	Referenced	Not addressed
DE (M,S)	Vignettes Examples Activities	Principles, strategies	Extensively described	Classroom	Policy references	Tech. integration addressed	Not addressed
DC (M,S)	Activities Graphics	Briefly discussed	Discussed	Classroom	Policy references	Ref. and described	Ref. to selecting texts
KY (M,S)	Ref. *Transformations*	Ref. *Transformations*	Ref. *Transformations*	Leads state assess.	Ref. *Transformations*	Ref. *Transformations*	Ref. *Transformations*
IL (M,S)	No examples	Not addressed	Not addressed	Not addressed	Not addressed	In vision statement and goals	None indicated
IN (M)	Examples Activities Graphics	In vision statement	Addressed, uses NCTM standards	Classroom, External account	Described	Standard for gr. 5-12	Suggestions
KS (M,S)	Examples, as part of benchmarks	Briefly discussed	Briefly discussed	Briefly mentions testing	Not addressed	Policy references	Brief policy references
LA (M,S)	In supplement	In rationale	Rationale for change provided	Rationale provided	Recommendations	Recommendations	Recommendations
MA (M,S)	Vignettes Examples Activities Diagrams	Strategies, examples	Extensively described	Classroom	Policy references	Discussed	Recommendation
ME (M,S)	Vignettes Activities Diagrams	Standards, strategies, examples	Examples	External account	Focus of framework	Discussed	Criteria and suggestions
MI (M,S)	Vignettes Examples Activities	Throughout	Briefly discussed	External account, Classroom	Ref. *Guidebook*	Not addressed	In *Guidebook, Framework*
MS	Strategies in *Math Guide*	Not addressed	Science recommend., *Math Guide*	Science classroom examples	Not addressed	Discussed	Ref. *Math Process Guide*
MO	Vignettes Examples Activities	Standards, strategies	Briefly discussed	Classroom, External account	Policy reference	Included in science, math	Math recommendations
NJ (M,S)	Math vignettes	In vision statement	Extensively addressed	External account	Addressed in math	Discussed in math	None indicated

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Elements One Through Eight

New Hampshire to Wisconsin

STATE (Subject)	Date/ Status	No. of Pages	Funding	Related Documents	Sources of Information	Development	Content Standards	Benchmarks/ Indicators
NH (M,S)	1995 (M) 1995 (S) Adopted	33M, 31S	State, IKE Prog. Dev.	*Addendum* — Benchmarks by grade	National and state documents	Math steps explained	8 math, 6 science K–12	6-8 per standard by grade cluster
NM (M,S)	1996 Adopted	13M, 20S	SSI, IKE grant	*Perf. Stds., '96; Assess. Blueprint*	Not indicated	Process explained	5 math, 8 science K–12	3-6 per standard by grade cluster
NY (M,S)	1996 Adopted	106	IKE grant	None indicated	Not indicated	Not specified	7 cross-disciplinary K–12	2-6 per standard by grade cluster
NC (S)	1994 Adopted	194	SSI, IKE Prog. Dev.	*Instr. Strategies Science* ('95)	ASCD, state documents	Steps explained	5 plus 1-4 by grade level/course	5-8 per standard by grade cluster
OH (S)	1994 Adopted	116	None indicated	*Guidelines, User Guide*	AAAS, CA	Not explained	4 science K–12	2-10 per standard by grade cluster
OR (M,S)	1996 Draft	50	Not indicated	None indicated	Not indicated	Not specified	10 math, 8 science by gr. 3, 5, 8, 10	1-3 per standard
PA (M,S)	1994 Adopted	116M, 121S	Not indicated	None indicated	NCTM, AAAS	Steps explained	7 math, 8 science K–12	1-4 per standard by grade cluster
RI (M,S)	1995 Adopted	101M, 311S	IKE grant	None indicated	NCTM, AAAS	Briefly explained	6 math gr. 4, 8, 10, 12; 4 science K–12	1-9 per standard by grade cluster
SC (S)	1995 Draft	123	SSI grant, state legis.	Document for teachers	National and state documents	Process explained	4 areas K–12, 3 strands per area	3-4 per strand by grade cluster
SD (M,S)	1996 Draft	15	SSI	*SD Content Standards*	NCTM, AAAS, NRC, NJ State doc.	Steps explained	6 math, 7 science K–12	16 per standard by grade cluster
TN (S)	1995 Adopted	51	Not indicated	None indicated	National and state documents	Process explained	24 themes, 2-3 stds. per theme	1-6 per standard by grade cluster
TX	1996 (M) Draft 1996 (S) Draft	79M, 81S	SSI funds	Math. *Basic Underst., Perf. Desc.*	Not indicated	Steps explained	6 math, 6 science basic understandings, 20+ knowledge/skills by grade cluster	2-4 per know./skill by grade cluster
UT (M,S)	1995 (M) Adopted 1995 (S) Adopted	99M, 63S	Not indicated	*Elem. Core Curric.*	NRC, AAAS	Math briefly explained	10-14 math, 7 science by 7-12 course	40 math, 20 science per course
VT (M,S)	1996 Adopted	24	SSI, FIRST, Carnegie funds	*Core Connections*	NCTM, NRC	Process explained	8 integrating math, science, technology K–12	1-10 per standard by grade cluster
VA (M,S)	1996 Adopted	101	Not indicated	None indicated	None indicated	Briefly explained	6 math by grade K-8 and course 9-12; 6 science by grade K–6 and course 7–12	6-30 per standard
WA (M,S)	1996 (M) Draft 1996 (S) Adopted	11M, 24S	None indicated	*Essential Academic Learning Requiremt*	NRC, AAAS	Science process explained	5 math by gr. 3, 4, 7, 10, K–12; 4 science, 4-10	15-20 per standard by grade level (M), grade cluster (S)
WI (S)	1996 Draft	21	Not indicated	None indicated	NRC	Not addressed	9 science K–12	5-6 per standard by grade cluster

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Elements NineThrough Fifteen

New Hampshire to Wisconsin

STATE (subject)	Communication	Equity	Pedagogy	Assessment	Professional Development	Use of Technology	Materials and Texts
NH (M,S)	Vignettes, Examples, Activities	Briefly discussed	Described in both	Classroom, External account.	Addressed	Major category	Not addressed
NM (M,S)	No examples	Not addressed; Ref. Tech. Assist. document	Not addressed	Ref. *Assess Blueprint*	Not addressed	Not addressed	Not addressed
NY (M,S)	Examples Activities Diagrams	Not addressed	Extensively described	Not addressed	Not addressed	Integration addressed	Recommends, suggests
NC (S)	Activities	In vision statement	Activities, suggestions	Classroom progress	Not addressed	Not addressed	Not addressed
OH (S)	Vignettes Examples Activities	Briefly mentioned	Extensively described	Perf. obj's, Classroom, External account.	Not addressed	Referenced	Recommendations and suggestions
OR (M,S)	Benchmarks, Performance. Stds.	Not addressed	Not addressed	Perform. standards, sample items	Not addressed	In science section	Not addressed
PA (M,S)	Science Examples, Activities	Strategies	Discussed	Classroom (science) examples, rubrics	Not addressed	Referenced in science	Science recommendations
RI (M,S)	Vignettes Examples Activities Diagrams	Standards, strategies	Extensively described	Classroom, External, Reference	Referenced	Referenced	Recommends and suggests
SC (S)	Vignettes Examples Activities	Briefly discussed	Extensively described	Assessment Chapter	Referenced	Referenced	Not addressed
SD (M,S)	No examples	Ref. SD *Content Standards*	Ref. SD *Content Standards*	Ref. SD *Content Standards*	Ref. SD *Content Standards*	Advocated	Not addressed
TN (S)	Vignettes Diagrams	Briefly discussed	Briefly discussed	Classroom	Not addressed	Not addressed	Not addressed
TX (M,S)	Science Activities/Tasks	Not addressed	Briefly mentioned	Plans	Not addressed	Not addressed	Science recommends and suggests
UT (M,S)	No examples	Briefly discussed	Brief discussion	Use of CRT, NRC, Perf.	Not mentioned	Referenced	Not addressed
VT (M,S)	Examples Activities/Tasks Diagrams	Briefly discussed	Extensively described	External, Classroom	Not addressed	Referenced	Not addressed
VA (M,S)	No examples	Not discussed	Not addressed	Not addressed	Not addressed	Not addressed	Not addressed
WA	Outline of concepts	Not addressed	Science briefly discussed	Science to be designed	Not addressed	Not addressed	Not addressed
WI (S)	No examples	Not addressed	Not addressed	Not discussed	Not addressed	Not addressed	Not addressed

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Chapter Four

State Dissemination and Implementation of Standards and Frameworks: A Graphic Depiction

Our state-by-state survey of the status of state standards and frameworks found that 46 states had written and published new state curriculum frameworks or content standards in mathematics and science. Another survey of states conducted by the Council in 1996 reported that 34 states had content standards completed and ready for implementation in mathematics, English/language arts, science, and social studies (CCSSO, *Key State Education Policies on K–12 Education*, 1996). Considering these state efforts, a central question being asked by educators, decision-makers, and researchers is: "How are these state standards and policies going to be put into practice in schools?"

The design for our study included a series of interviews with state curriculum specialists to identify what kinds of activities states have underway to disseminate their standards documents, and to determine the main approaches to standards strategies states are using. We asked state specialists to identify the "primary strategies" being used by the state departments of education to disseminate and implement standards at the local level. Complete information was reported by 39 state specialists (11 states did not report or do not have completed standards) during the spring and summer of 1996. The following table provides a graphic display of each state's responses.

Readers that are interested in learning more about the implementation strategies of states in mathematics and science can refer to the CCSSO Web page for further details from the interviews with state specialists. Information is provided in response to two questions: how states have focused implementation efforts, and how the role of the state agency has changed within the development of standards.

Summary of Findings

Number of copies distributed: The total distribution of copies of standards or frameworks documents varied by state from less than a thousand in several states to more than 30,000 copies in North Carolina and Oklahoma and 100,000 copies in New York.

Audiences for the frameworks or standards documents: The primary audiences for the documents appear to be divided into two types: (a) states that viewed curriculum committees or curriculum specialists and school administrators as primary audiences, and (b) states that specified teachers as the primary audience or one of the primary audiences. Several states explicitly designed their framework or standards to be used by schools and districts in developing curriculum with teachers, but not as a guide for individual teachers.

Other resources and media: Twenty-four states reported they are disseminating frameworks or standards electronically through a state Internet Web site. In addition, 17 states reported using videos, public television, or cable/satellite connections to disseminate information. Some states also have looseleaf binders, modules for professional development, or other printed resource materials related to standards.

Primary strategies for implementation: Almost all states reported professional development workshops or conferences as a primary strategy. More specifically, many states are holding sessions with districts on writing curriculum. Regional networks of schools and teachers have been formed within states. Linking content standards with state assessments was identified in half the states, and work with teacher certification standards was frequently identified as a state implementation strategy.

Note: This chapter is available on the CCSSO Web page (www.ccsso.org).

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State Dissemination and Implemention of Standards and Frameworks

Strategies in Mathematics and Science

STANDARDS/FRAMEWORKS	DISSEMINATION			IMPLEMENTATION
STATE/ Document	**No. of Copies**	**Audiences**	**Other Resources, Media**	**Primary Strategies**
ALABAMA *Course of Study: Mathematics* ('89) *Course of Study: Science* ('95)	30,000	Elementary and Secondary Teachers	—	Professional development workshops State assessment program
ALASKA *Mathematics and Science Framework* ('96)	2,000	Curriculum Committees	Resource Kit, Resource Notebook, Web, CD, Video	Local curriculum writing Teaching guides Summer institutes Teacher certification with standards Pilot assessments: 14 sites
ARKANSAS *Mathematics Framework* ('94) *Science Framework* ('94)	2,000	Teachers, Superintendents, Curriculum Supervisors	Web	State assessment program Summer institutes State/regional networks Interactive technology
CALIFORNIA *Mathematics Framework* ('92) *Science Framework* ('94)	—	All schools, as requested	—	Professional development workshops Local curriculum writing
COLORADO *Content Standards, Mathematics* ('95) *Content Standards, Science* ('95)	3,000 M 2,000 S	School Board Presidents, Superintendents, LEA Specialists, Professional Organizations	—	State assessment program Workshops
CONNECTICUT *Guide to Curriculum Development, Mathematics* ('81) *Guide to Curriculum Development, Science* ('91)	1,500	Teachers, Curriculum Committees, Administrators	—	Local curriculum writing assistance State Assessment program Professional development
DELAWARE *Mathematics Framework* ('95) *Science Framework* ('95)	20,000	Teachers	Web, Video	Local curriculum writing assistance Professional development workshops
DEPARTMENT OF DEFENSE EDUCATION ACTIVITY *Mathematics Standards* ('94)	750	All Schools, Teachers	—	Professional development Teaching guides
DISTRICT OF COLUMBIA *Mathematics, Science, and Technology Frameworks* ('95)	750	Teachers	Video	Year-round professional development Summer institutes
GEORGIA *Quality Core Curriculum K–12* ('89)	300	Curriculum Directors, Superintendents, Regional Agencies, Deans, Colleges	Electronic network	State assessment program Workshops Local curriculum writing assistance
ILLINOIS *Academic Standards* (Draft, '96)	20,000	All Schools, Universities, Professional Organizations, Business Groups	Web	State assessment program State/regional networks Professional collaboratives Curriculum assistance for teachers Workshops

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STANDARDS/FRAMEWORKS	DISSEMINATION			IMPLEMENTATION
STATE/ Document	**No. of Copies**	**Audiences**	**Other Resources, Media**	**Primary Strategies**
INDIANA				
Mathematics Proficiency Guide (Draft '96) *High School Mathematics Competencies* ('95) *Science Proficiency Guide* ('93) *High School Science Competencies* ('95)	—	—	Web for Science	Public forums for teachers to edit Professional development through regional service centers Proficiency guides
KANSAS				
Mathematics Standards ('93) *Standards for Science* ('95)	15,000 M 2,000 S	Teachers, Administrators, School Boards, Community, Parents, Higher Education	Web, Videos of Math and Science practice	State assessment process School accreditation process Training workshops
KENTUCKY				
Transformations: Kentucky's Curriculum Framework (Revised '95) *Core Content Standards* ('96)	All Districts	Curriculum Committees	Web	Professional development Regional networks led by expert teachers Portfolios for state assessment
LOUISIANA				
Mathematics Framework ('95) *Science Framework* ('96) Supplements	1,500 M 600 S	Teachers, Curriculum Directors	Looseleaf binders	Professional development Local curriculum writing New assessment program
MAINE				
Framework for Mathematics and Science ('95)	8,000	Teachers and Administrators attend workshop or purchase	Web, Assessment Modules, Addenda	Improve teachers' understanding of pedagogy, content, and grade to grade strands
MARYLAND				
Mathematics Framework ('85) *High School Assessment Core Goals* ('96) *Science Framework* ('85) *High School Assessment Core Goals* ('96)	5,000	All Schools, Superintendents	—	Develop local curriculum Teacher training—professional development workshops
MASSACHUSETTS				
Mathematics Framework ('95) *Science and Technology Framework* ('95)	20,000 per subject	Superintendents, Principals, Department Heads	Web, Video	Revamped state assessment Teacher recertification Professional development Summer content institutes
MISSISSIPPI				
Mathematics Structure ('95) *Mathematics Process Guide* ('95) *Science Framework* ('96)	2,000	Superintendents, Curriculum Coordinators	Web, Educational TV, Hard copy, Disk	Assistance with local curriculum District level workshops Interactive network training
MISSOURI				
Mathematics Framework ('96) *Science Framework* ('96)	2,000 per subject	School Districts, Curriculum Coordinators, All Schools	Web, Video, Text	Teach teachers frameworks principles Assess students' mastery through state exams Professional development through nine regional centers
MONTANA				
Mathematics Framework ('96)	1,000	Local Curriculum Development Team	Looseleaf binders with Tool Kit for Math/Science	Professional development workshops Higher education courses State/regional networks or collaboratives
NEBRASKA				
Mathematics and Science Frameworks ('94) Addendum ('95)	9,000	Teachers, Administrators, Specialists	ERIC	Teach teachers about frameworks

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State Dissemination and Implemention of Standards and Frameworks? (cont'd)

STANDARDS/FRAMEWORKS	DISSEMINATION			IMPLEMENTATION
STATE/ Document	**No. of Copies**	**Audiences**	**Other Resources, Media**	**Primary Strategies**
NEVADA *Mathematics Course of Study* ('94) *Science Course of Study* (developing)	10,000 M	Curriculum Supervisors, Teachers	Web, Video	Train the trainers model for teachers: how to implement the curricula
NEW HAMPSHIRE *Mathematics Framework* ('95) *Science Framework* ('95)	3,000 per subject	Superintendents, Principals, Teachers	Web, Instructional Materials	Workshops on framework on state Web page Assistance with local curriculum State assessment program Higher education teacher training
NEW JERSEY *Core Content Standards* ('96) *Mathematics Framework* ('95)	10,000 per subject	Superintendents, Principals, Local Boards	Web	Help districts align curriculum with standards Help districts prepare for state assessment
NEW YORK *Learning Standards for Mathematics, Science, and Technology* ('96)	85,000 – 100,000K	K-12 Teachers	Web	Tie all instructional innovations to new assessments
NORTH CAROLINA *Mathematics Course of Study* ('94) *Science Course of Study* ('94)	40,000 M 33,000 S	Teachers	Video	Preparation for state assessment Professional development workshops Teaching guides
NORTH DAKOTA *Frameworks—Math* ('93) *Frameworks—Science* ('93)	500	All Schools	Web, Video	Educate teachers on use of framework Training workshops at eight regional centers Goal: five days per teacher
OHIO *Mathematics: Competency Based Program* ('90) *Science: Competency Based Program* ('90)	15,000 S	All Schools, Colleges, Universities	Math Model Assessments, Science Hypercard Model Tools	Professional development Teaching guides State/regional collaboratives Emphasis on HOTS in content areas
OKLAHOMA *Academic Skills* ('93)	50,000 per subject	Teachers	—	Professional development workshops State assessment program Upgraded teacher certification requirements
OREGON *Goals, Standards, and Benchmarks* ('96)	3,000	Teachers, Curriculum Coordinators, Superintendents, Parents, Business leaders, Legislators	Web, CD ROM with models	Workshops for teachers and experts Upgraded teacher certification Teaching guides New state assessment
RHODE ISLAND *Mathematics Framework* ('95) *Science Framework* ('95)	3,500 per subject	Curriculum Supervisors, Teachers (at workshops)	Web, Video	Training—state's regional consortia Curriculum design and workshop activities
SOUTH CAROLINA *Mathematics Framework* ('93) *Science Framework* ('95)	6,000–8,000 S	Teachers, Coordinators, Administrators, Colleges and Universities	Video	Professional development workshops New state assessment program Higher education courses Upgraded teacher certification Regional curriculum development Math summer institutes SSI courses on frameworks

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STANDARDS/FRAMEWORKS	DISSEMINATION			IMPLEMENTATION
STATE/ Document	**No. of Copies**	**Audiences**	**Other Resources, Media**	**Primary Strategies**
SOUTH DAKOTA				
Mathematics Standards ('96) *Science Standards* ('96)	200 M 2,000 S	Administrators, Teachers	Web, Resource finder, TV, satellite	Professional development workshops Local curriculum writing assistance State assessment program Upgraded teacher certification Math awareness workshops Science professional development: role of standards and how to develop curriculum
TENNESSEE				
Mathematics Curriculum Guide, K–8, Framework, 9–12 ('92) *Science Framework K–12* ('95)	2,000 M 500 S	Districts—distribution to teachers	Web	Regional workshops connect curriculum with national standards Teaching guides
TEXAS				
Mathematics Essential Knowledge and Skills (Draft, '96) *Science Essential Knowledge and Skills,* (Draft, '96)	20,000 per subject	Teachers, Curriculum Specialists, PTA , Business and Industry	Web, Video	Workshops teach about frameworks
UTAH				
Mathematics Core Curriculum, K–4, 5–7, 7–12 ('93, '95) *Science Core Curriculum*, K–6, 7–12 ('94, '95)	10,000+	Teachers, Specialists, Administrators	Public TV, Teacher resource books	Math train the trainer workshops for professional development Requirements for subject-level recertification Direct training for 3,000 teachers
VERMONT				
Framework of Standards ('96)	—	Teachers	Video, Teacher networks, Workshop binders	Professional development to educate teachers about expectations Upgraded assessment system New certification requirements Local curriculum writing and develop.
VIRGINIA				
Mathematics Standards ('95) *Science Standards* ('95)	4,000 per subject	Teachers, Interest groups, Principals, Department heads	Web, Video, Satellite Interactive technology	Summer institutes New assessment system Regional networks
VIRGIN ISLANDS				
Mathematics Framework ('95) *Science Curriculum Framework* ('95)	—	—	—	Professional development workshops Teaching guides State/regional collaboratives State assessment program
WASHINGTON				
Essential Learning Requirements: Mathematics ('96); *Science* ('96)	10,000 S	Teachers, School Board Legislators, Parents	Web, Public TV	Regional Training Center Make opportunities available to all
WEST VIRGINIA				
Goals and Objectives for Mathematics, Science (Draft, '96)	—	County Offices, Principals	Internet	Professional development workshops State assessment program Standards based on national math and science standards

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Chapter Five

Examples of Mathematics and Science Standards and Benchmarks in 32 States

One of the goals of the CCSSO study of new state frameworks and standards was to graphically display how states have written content standards in mathematics and science, and to provide a way to examine differences between the states. Discussions of what states have done with content standards, and the different approaches to the development task, have proceeded without a clear idea of what the similarities and differences are among state standards. The Council decided it was important to design a method of summarizing and presenting state standards, and the associated benchmarks or indicators.

In this chapter, we present part of the information produced from the 1996 concept mapping analysis of new state standards and frameworks in mathematics and science conducted by research staff at CCSSO and Policy Studies Associates. The analysis included all state standards and frameworks documents—a total of 32 states, DC, and DoDEA—that were completed from 1994 through mid-1996.

In the following summaries from these state standards and frameworks documents, we provide the following information:

- Short description of what is contained in the document
- State definition of standards and benchmarks/ indicators
- Number of "standards," according to state definition, average number of benchmarks or indicators per standard, and grade levels covered by standards and benchmarks.
- Lists of main standards in mathematics and science
- Cross-cutting expectations or themes (if present)
- Example of state standard and associated benchmarks for Mathematics—Algebra, at grades 5–8
- Example of state standard and associated benchmarks for Science—Cell, at grades 5–8.

Chapter Three includes a matrix of the number of standards in each state document and the average number of benchmarks per standard.

Note: This chapter is available on the CCSSO Web page (www.ccsso.org).

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Alabama

Science Standards and Examples

Source

Alabama Course of Study: Science (1995)

The document is an outline of the grade and course requirements, revised to reflect higher expectations, new views of teaching and learning, and assessment. The volume includes an introductory chapter on Instruction-Related Elements of K–12 Science Program and is supplemented by a volume of suggested resources and other information about implementing the new curriculum goals.

	CONTENT STANDARDS	BENCHMARKS/INDICATORS
Alabama's Term	"Strands"	"Content Standards"
Alabama's Definition	—	Statements of what students should know and be able to do ... the minimum required content ... at the conclusion of a course as stated in State code.
Number	10 Science K–8 by grade, 9–12 by course	Average 5 per strand (approximately 50 total per grade/course)

Science Standards

1. Earth and Science
   - Universe
   - Earth in space
   - Dynamic Earth
2. Physical Science
   - Matter
   - Energy
   - Force and motion
3. Life Science
   - Diversity
   - Heredity
   - Cells
   - Interdependence

Cross-Cutting Expectations/Themes

- Scientific process
- Scientific knowledge
- Scientific applications

Examples of Content Standards and Benchmarks

Standard: Ages 9–12

Science

Life science: Cells

(p. 92)

Benchmarks for this Standard

1. Relate microorganisms that invade the human body to common diseases.
2. Describe how simple components of the immune system attach blood-borne pathogens and foreign materials in the human body.
3. Identify natural substances produced by the human body and the alternate sources from which they are obtained today.
4. Compare the complexity of circulatory and nervous systems in earthworms, frogs, and humans.

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Alaska

Mathematics and Science Standards and Examples

Source

Alaska Mathematics and Science Framework (1996)

The curriculum framework, part of Alaska's Goals 2000 initiative, was written by committees of educators and experts and revised over a several-year period through multiple public mailings and meetings. The framework includes the Alaska Content Standards in Mathematics and Science. Supporting materials are a Reference Kit and a Resource Notebook.

STATE	CONTENT STANDARDS	BENCHMARKS/INDICATORS
Alaska's Term	"Content Standards"	"Benchmarks"
Alaska's Definition	What students should know, be able to do, and be committed to, in specific content areas (glossary).	Specific examples of developmentally appropriate experiences for students at specific levels (p. 3:2)
Number	5 Mathematics, 4 Science	4-6 benchmarks per standard by age cluster: ages 8-10, 12-14, 16-18 (M)
	Standards cut across grade levels	3-5 benchmarks per standard by age cluster: ages 6-7, 8-10, 12-14, 16-18 (S)

Mathematics Standards

1. Content of Math: Understand mathematical facts, concepts, principles and theories
   - Numeration: Understand and use the concept of numbers, number systems and numeration
   - Measurement: Select and use appropriate systems, units and tools of measurement
   - Estimation and computation
   - Functions and relations
   - Geometry
   - Statistics and probability
2. Problem Solving: Understand, select and use a variety of problem-solving strategies
   - Use computational methods and appropriate technology as problem-solving tools.
   - Use problem-solving to investigate and understand mathematical content.
   - Formulate mathematical problems that arise from everyday situations.
   - Develop and apply strategies to solve a variety of problems.
   - Check the results against mathematical rules.
   - Use common sense to interpret results.
   - Apply what was learned to new situations.
   - Be able to use mathematics with confidence.
3. Communication: Will understand, form and use appropriate methods to define and explain mathematical relationships
   - Express and represent math ideas
   - Relate math terms to everyday language
   - Develop, test, and defend math hypotheses
   - Clarify math ideas through discussion
4. Reasoning: Will use logic and reason to solve problems
   - Analyze situations
   - Draw logical conclusions
   - Use models, facts and relations to explain
   - Verify conclusions, judge validity and construct arguments
   - Recognize patterns and form math propositions
5. Connections: Will apply mathematical concepts and process to situations within and outside of school
   - Explore problems and describe results
   - Use mathematics in daily life
   - Use mathematics in other curriculum areas

Science Standards

The Science Content Standards represent an integrated approach placing greater emphasis on inquiry skills involving science process and reasoning skills rather than memorization of facts.

1. Content of Science: Understand scientific facts, concepts, principles, and theories [16 key elements]
   - Structure of matter
   - Changes and interactions of matter
   - Universe
   - Earth
   - Forces of nature
   - Motion
   - Processes that shape the earth
   - Energy transformations
   - Flow of matter and energy
   - Cells
   - Heredity
   - Diversity
   - Evolution through natural selection
   - Interdependence
   - Local knowledge
   - Relativity
2. Scientific Inquiry: Will understand and develop the skills of scientific inquiry [six key elements]
   - Use the process of science
   - Design and carry out scientific investigations using appropriate instruments
   - Different ways of thinking, curiosity
   - Aspects of inquiring including integrity, skepticism, creativity
   - Ethical standards
   - Safety procedures
3. Nature and History of Science: Will understand that the content and conduct of science are influenced by historical, social, cultural, and environmental contexts in which they occur [eight key elements]
4. Applications of Science and Technology to Personal and Community Life: Will apply scientific knowledge and skills to make reasoned decisions about the use of science and scientific innovations [six key elements]

Examples of Content Standards and Benchmarks

Standard: Ages 12–14

Mathematics

Functions and Relations:

All Alaska students will represent, analyze and use mathematical patterns, relations, and functions, using methods such as tables, equations, and graphs.

Benchmarks for this Standard

1. Represent patterns and relationships using concrete items, tables, graphs, and simple equations.
2. Draw connections between these four types of representations.
3. Analyze functions to determine what pattern or rule can be used to explain how a change in one value results in or is the result of a change in other values.
4. Understand and use the rectangular coordinate system and linear equations.

Standard: Ages 12–14

Science

Cells are part of Science Standard 1 (10):

Know that living things are made up mostly of cells and that all life processes occur in these basic units.

Benchmarks for this Standard

1. Use a microscope to show that larger organisms are made of cells and that these cells may have specific functions.

Colorado

Mathematics and Science Standards and Examples

Sources

Colorado Model Content Standards for Mathematics (1995)
Colorado Model Content Standards for Science (1995)

The Colorado State Legislature mandated the content standards. Primary funding comes from the state's SSI, Eisenhower grants, Title VI, and local districts. A revised state assessment system that is aligned with the standards was also mandated by the state legislature. The development and dissemination of information about the standards-based education system has been funded by the legislature, in conjunction with the state's SSI grant.

	CONTENT STANDARDS	BENCHMARKS/INDICATORS
Colorado's Term	Model Content Standards	No term is given
Colorado's Definition	A compilation of specific statements of what a student should know or be able to do relative to a particular academic area	What students know and are able to do
Number	6 Mathematics, 6 Science	4-7 per standard, math; 4 per standard, science
	Content standards apply to all grades	PreK, K–4, 5–8, 9–12

Mathematics Standards

1. Students develop number sense and use numbers and number relationships in problem-solving situations and communicate the reasoning used in solving these problems.
2. Students use algebraic methods to explore, model, and describe patterns and functions involving numbers, shapes, data, and graphs in problem-solving situations and communicate the reasoning used in solving these problems.
3. Students use data collection and analysis, statistics, and probability in problem-solving situations and communicate the reasoning used in solving these problems.
4. Students use geometric concepts, properties, and relationships in problem-solving situations and communicate the reasoning used in solving these problems.
5. Students use a variety of tools and techniques to measure, apply the results in problem-solving situations, and communicate the reasoning used in solving these problems.
6. Students link concepts and procedures as they develop and use computational techniques, including estimation, mental arithmetic, paper and pencil, calculators, and computers, in problem-solving situations and communicate the reasoning used in solving these problems.

Science Standards

1. Students understand the processes of scientific investigation and design, conduct, communicate about, and evaluate such investigations.
2. Physical Science: Students know and understand common properties, forms, and changes in matter and energy.
3. Life Science: Students know and understand the characteristics and structure of living things, the processes of life, and how living things interact with each other and their environment.
4. Earth and Space Science: Students know and understand the processes and interactions of Earth's systems and the structure and dynamics of Earth and other objects in space.

Science Standards (cont'd)

5. Students know and understand interrelationships among science, technology, and human activity and how they can affect the world.

6. Students understand that science involves a particular way of knowing and understand common connections among scientific disciplines.

Cross-Cutting Expectations/Themes

- Three questions guide the development of this document: What is mathematics? What does it mean to know, use, and do mathematics? and, What mathematics should every Colorado student learn?

- Students should take an active role in learning math by developing number sense, using algebraic methods and data collection analyses and geometric concepts, applying results to communicate problems and link concepts and procedures as they develop and use computational techniques.

Examples of Content Standards and Benchmarks

Standard: Grades 5–8

Mathematics

Students use algebraic methods to explore, model, and describe patterns and functions involving numbers, shapes, data, and graphs in problem-solving situations and communicate the reasoning used in solving these problems.

(p. 8)

Benchmarks for this Standard

1. Representing, describing, and analyzing patterns and relationships using tables, graphs, verbal rules, and standard algebraic notation
2. Describing patterns using variables, expressions, equations, and inequalities in problem-solving situations
3. Analyzing functional relationships to explain how a change in one quantity results in a change in another (for example, how the area of a circle changes as the radius increases, or how a person's height changes over time)
4. Distinguishing between linear (definition provided in glossary of terms) and nonlinear functions through informal investigations
5. Solving simple linear equations in problem-solving situations using a variety of methods (informal, formal, graphical) and a variety of tools (physical materials, calculators, computers)

Standard: Grades 5–8

Science

Life Science: Students know and understand characteristics and structure of living things, the processes of life, and how living things interact with each other and their environment. (Focus: Biology—Anatomy, Physiology, Botany, Zoology, Ecology).

Sub-standard 3.3: Students know and understand how the human body functions, factors that influence its structures and functions, and how these structures and functions compare with those of other organisms.

(p. 14)

1. Describing the observable components and functions of a cell (for example, cell membrane, nucleus, cytoplasm, chloroplasts; movement of molecules into and out of cells)
2. Comparing and contrasting the basic structures and functions of different types of cells (for example, single-celled organisms in pond water, Elodea, onion cell, human cheek cell)
3. Describing the growth and development of several organisms (for example, embryonic development of vertebrate)
4. Describing the structures and functions of human body systems
5. Describing and giving examples of noncommunicable diseases and communicable diseases (for example, heart disease and chicken pox)

Delaware

Mathematics and Science Standards and Examples

Sources

Delaware Mathematics Curriculum Framework: Content Standards, Vol. I and II (1995)

Delaware Science Curriculum Framework: Content Standards, Vol. I and II (1995)

The two volumes present content standards, performance indicators, learning events and vignettes, and classroom performance models. The two frameworks share common sections on state vision, frameworks structures, equity principles, goals of "New Directions." They differ slightly in the added information they provide about development and processes for reading the documents.

	CONTENT STANDARDS	BENCHMARKS/INDICATORS
Delaware's Term	"Content Standards"	"Performance Indicators"
Delaware's Definition	Define what every Delaware student should know and be able to do	Clearly articulate the specific expectations of students in the grade-level clusters from kindergarten through tenth grade.
Number	10 Mathematics, 8 Science K–3, 4–5, 6–8, 9–12	Math: 3-12 per standard Science: 3-12 per standard K–3, 4–5, 6–8, 9–10

Mathematics Standards

1. Problem Solving
2. Mathematical Communication
3. Mathematical Reasoning
4. Mathematics Connections
5. Estimation, Measurement and Computation
6. Number Sense
7. Algebra
8. Spacial Sense and Geometry
9. Statistics and Probability
10. Patterns, Relationships and Functions

Science Standards

1. Nature and Applications of Science and Technology
2. Materials and Their Properties
3. Energy and Its Effects
4. Earth in Space
5. Earth's Dynamic Systems
6. Life Processes
7. Diversity and Continuity of Living Things
8. Ecology

Cross-Cutting Expectations/Themes

- Educational excellence and equity for all
- Collaboration and partnerships among educators, parents, family, business and the community
- Safe and supportive environment that respects diversity of learners
- Sense of vitality, energy, and commitment to successful teaching and learning

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Examples of Content Standards and Benchmarks

Standards: Grades 5–8

Mathematics

Algebra: Students will develop an understanding of Algebra by solving problems in which there is a need to progress from the concrete to the abstract using physical models, equations, and graphs; to generalize number patterns; and to describe, represent, and analyze relationships among variable quantities.

(pp. 41-50)

Benchmarks for this Standard

- Solve linear equations using concrete, informal, and formal methods.
- Model and solve real-world and mathematical problems using algebraic methods.
- Evaluate algebraic expressions and formulas for given values of the variable.
- [3 additional]

Standards: Grades 5–8

Science

Life Processes: The natural world is defined by organisms and life processes which conform to the principles regarding conservation and transformation of matter and energy. Students will learn how living organisms use matter and energy to build their structures and conduct their life processes. They will learn the mechanisms and behaviors used by living organisms to regulate their internal environments and to respond to changes in their surroundings. Students will also study how knowledge about life processes can be applied to improving human health and well being.

(pp. 55-57)

Benchmarks for this Standard

- The basic unit of all living organisms is the cell. In multi-cellular organisms, different cells are specialized to perform various tasks, and cells similar in shape and function are organized into groups (e.g. muscle cells, motor nerve cells).
- Cells contain a set of observable structures ...
- Unicellular organisms perform, within a single cell, all of life's specific functions ...
- [6 additional]

Department of Defense Education Activity

Mathematics Standards and Examples

Source

Mathematics Standards and Expectancies (1994)

The document summarizes changes in mathematics instruction, the need for updating the curricula in response to these changes, and important issues for math educators, such as equity and effective instructional practices. The standards and expectancies (similar to benchmarks) are printed in a list format for each grade and for all secondary courses, and examples of what students who have achieved proficiency should be able to do are provided for each grade K–8 and for each secondary course.

	CONTENT STANDARDS	BENCHMARKS/INDICATORS
Department of Defense's Term	"Content Standards"	"Expectancies"
Department of Defense's Definition	Standards are based on criteria developed by the NCTM and provide a broad overview of the mathematics curriculum.	Intended to assist teachers by providing specific guidance for teachers in weekly and monthly planning.
Number	10 standards for K-4, 11 for 5-8, 14 for 9-12 courses	5 per standard K-4, 5-8, specific secondary grade courses

Mathematics Standards

K–4

1. Problem Solving
2. Communication
3. Reasoning
4. Connections
5. Computation and Estimation
6. Number Sense, Number Operations, and Number Relationships
7. Patterns, Relationships, and Functions
8. Probability and Statistics
9. Geometry
10. Measurement

5–8

1. 1–10 (see K–4)
2. Algebra

9–12

(Example: Introductory Algebra/Geometry Course)

1. Functions
2. Geometry from a Synthetic Perspective
3. Geometry from an Algebraic Perspective
4. Trigonometry
5. Statistics
6. Probability
7. Discrete Mathematics
8. Conceptual Underpinnings of Calculus
9. Mathematical Structure

Courses 9–12

- Introductory Geometry/Algebra
- Algebra with Geometry, Course I
- Geometry with Algebra, Course II
- Algebra with Geometry, Course III
- Math Analysis
- AP Calculus
- AP Calculus via Telecommunications

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Cross-Cutting Expectations/Themes

At all grade levels, the following themes are to be integrated and emphasized:

- Problem solving
- Communicate mathematical ideas and concepts in verbal and written form
- Reasoning
- Connecting mathematics to realistic situations

Examples of Content Standards and Benchmarks

Standard: Grades 5–8

Middle grades algebra

In grades 5–8, the mathematics curriculum should include explorations of algebraic concepts and processes so that students can:

Benchmarks for this Standard

1. Understand the concepts of variable, expression, and equation.
2. Represent situations and number patterns with tables, graphs, verbal rules, and equations and explore the interrelationships of these representations.
3. Analyze tables and graphs to identify properties and relationships.
4. Develop confidence in solving linear equations using concrete, informal, and formal methods.
5. Investigate inequalities and nonlinear equations informally.
6. Apply algebraic methods to solve a variety of real-world and mathematical problems.

District of Columbia

Mathematics and Science Standards and Examples

Source

District of Columbia Mathematics, Science, and Technology Curriculum Frameworks, Grades K–12 (1995)

A cross-disciplinary framework that introduces content standards and indicators, and explains the "performance-based education (PBE)" strategy as it is. The document includes an introduction and two final chapters that apply the broad outlines of PBE to mathematics and science content. Although there are few examples of specific suggestions for teaching the mathematics and science content standards, charts and diagrams scattered liberally throughout the text suggest activities that connect the content areas to one another and to teaching processes that reflect a constructive, learner-centered approach.

	CONTENT STANDARDS	BENCHMARKS/INDICATORS
District of Columbia's Term	"Content Standards"	"Performance Indicators"
District of Columbia's Definition	Describe the discipline's key concepts and processes. (pp. I-6)	Describe what students should know and be able to do by the end of grades 3, 5, 8, and 11. They are targets for student learning, to be used by teachers to help set priorities.
Number	7 Mathematics, 6 Science 2 Technology per grade 3, 5, 8, 11	4-6 per standard 3, 5, 8, 11

Mathematics Standards

1. Number Sense and Estimation
2. Numeration Systems
3. Measurement
4. Algebraic Concepts and operations
5. Geometry and Spatial Sense
6. Patterns, Relationships, and Functions
7. Probability and Statistics

Science Standards

1. Scientific inquiry
2. Life Sciences
3. Earth Sciences
4. Physical Sciences
5. Space Sciences
6. Systems

Technology Connections

1. Content
2. Instruction
3. Assessment

Cross-Cutting Expectations/Themes

The "performance-based learning actions wheel," included in each content area emphasizes the importance of focusing on "actual student demonstrations of learning." Learning events must incorporate these "actions:"

- Accessing information
- Interpreting information
- Producing something new
- Disseminating learning to an audience
- Evaluating the learning performance

Examples of Content Standards and Benchmarks

Standard: Grade 8

Mathematics

Algebra: During middle school, students should build on their informal algebra experiences and apply algebraic methods to the solution to real world problems. They should develop confidence in solving linear equations by formal methods as well as through the use of technology.

1. Apply the concepts of variable expression and equation.
2. Represent situations and number patterns with tables, graphs, rules, and equations and explore the interrelationship of these representations.
3. Analyze tables and graphs to identify properties and relationships.
4. Develop confidence in solving linear equations using concrete, informal and formal methods.
5. Investigate inequalities and nonlinear equations ... through the use of technology.
6. Apply algebraic methods to solve problems based on practical applications.

Standard: Grade 5

Science

Life Sciences: Students observe and investigate the characteristics of living things and explain their similarity, diversity, interrelationship, and classification.

1. Describe the conditions needed to sustain life.
2. Describe the levels of organization in organisms (cells, tissues, organs, and systems).
3. Identify features of organisms which enable them to survive in the conditions where they normally live [see original for added related examples].

Illinois

Mathematics and Science Standards and Examples

Source

Illinois Academic Standards in Learning Areas (draft, 1996)

Once the standards are complete, state assessments will be improved to more accurately measure student achievement at designated grade levels. In addition, the academic standards are expected to clarify the intended results of schooling for all audiences including educators, business partners, parents, students and the community; provide high academic standards and expectations for student learning across the state ensure continuity for students who move from one district to another; and create a clear set of expectations for student's performance that can be assessed at both state and local levels, as well as provide for individual student progress reporting.

	CONTENT STANDARDS	BENCHMARKS/INDICATORS
Illinois' Term	"Goals" and "Standards"	"Learning Benchmarks"
Illinois' Definition	None given	None provided
Number	3 Science goals, 5 Mathematics goals	1-4 per standard
	Goals and standards cover K–12	Early elementary, late elementary, middle/junior high, early high school, late high school

Mathematics Standards

1. Demonstrate knowledge and sense of numbers and their representation, including basic operations, ratios and proportions, by using multiple ways of obtaining exact values and estimates to understand patterns involving numbers and their applications.
2. Make, use, and estimate measurements of objects, amounts, and relationships and determine tolerable levels of error.
3. Identify and describe patterns and relationships in actual data, as well as solve problems and predict results using algebraic methods and symbols, tables, graphs, calculators and computers.
4. Analyze, categorize and draw conclusions about objects and spatial relationships using geometric methods and drawings, sketches, graphs, models, symbols, calculators, and computers.
5. Collect, organize, and analyze data using statistical methods and tables, charts, graphs, calculators and computers to represent processes, to predict results and to interpret uncertainty and change in practical applications.

Science Standards

1. Understand and apply the methods of scientific inquiry and technology design to investigate questions, solve problems, and analyze claims.
2. Understand the facts and unifying concepts of the life, physical and earth/space sciences.
3. Understand connections and relationships among science, technology and society.

Cross-Cutting Expectations/Themes

- Solving problems
- Communicating
- Using technology
- Working on teams
- Making academic connections

Examples of Content Standards and Benchmarks

Standard: Middle/Junior

Mathematics

Identify numerical relationships using variables and patterns.

(p. 36)

Benchmarks for this Standard

Solve problems using linear expressions, equations, and inequalities.

Standard: Middle/Junior

Science

Apply concepts of form and function within the sciences: Life Sciences.

(p. 14)

Compare and contrast how different forms and structures reflect different functions, e.g. identify similarities and differences among animals that fly, walk or swim; compare structures of plant cells to those of animal cells.

Indiana

Mathematics Standards and Examples

Sources

Indiana High School Mathematics Competencies (1995)

Mathematics Proficiency Guide (Draft, 1996)

Two interconnected documents lay out the state's mathematics expectations for grades K–12. The *Proficiency* document (for K–12) is approximately 250 pages long and includes the following components: proficiency statements, proficiency indicators, subskills, illustrative examples, and activities. The *Competencies*, "identifies what one would expect students to know and be able to do if their transcripts show successful completion of a particular mathematics topic."

	CONTENT STANDARDS	BENCHMARKS/INDICATORS
Indiana's Term	"Proficiency Statements"	"Proficiency Indicators"
Indiana's Definition	A general framework of skills, concepts and processes that all students should have an opportunity to acquire	Examples of behaviors which indicate that the proficiency is being acquired
Number	11 standards K–12	7 per standard K–4, 5–8, 9–12

Mathematics Standards

Grades K–12

1. Technology
2. Real Number Sense
3. Statistics and Probability
4. Communications
5. Place Value
6. Reasoning
7. Computation and Estimation
8. Connections
9. Geometry
10. Problem Solving
11. Measurement and Estimation

Additional Standards

Grades K–4

- Functions and Decimals
- Spatial Sense

Grades 5–8

- Ratios, Proportions, Percents
- Algebra

Grades 9–12

- Functions

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Examples of Content Standards and Benchmarks

Standard: Grades 5–8

Develop Explorations of Algebraic Concepts and Processes

(p. 95)

Benchmarks for this Standard

1. Use manipulatives and models to develop algebraic concepts.
2. Understand the concept of variable.
3. Represent points on a line or in a plane using numbers.
4. Write equations to represent problems involving equalities and inequalities.
5. Apply algebraic methods to solve a variety of real world and mathematical problems.
6. Recognize relationships among multiple representations of patterns and functions.
7. Utilize appropriate technology in the investigations of multiple representation of patterns and functions.
8. Explore slopes and intercepts of graphs of linear functions.

Kansas

Science Standards and Examples

Source

Kansas Curriculum Standards for Science (1995)

The Curriculum Standards document identifies processes of science in which students should achieve proficiency such as the "nature of science, the meaning of science communicated, the integration of science, and the relationships of social, technological, and scientific issues." Grade level benchmarks identify specific skills or thought processes students from grade level clusters should be able to perform.

	CONTENT STANDARDS	BENCHMARKS/INDICATORS
Kansas' Term	"Program Outcomes"	"Grade Level Benchmarks"
Kansas' Definition	No definition given	No definition is provided in the document
Number	5 all grade levels	1-6 per standard K–2, 3–5, 6–8, 9–12

Science Standards

1. Nature of Science
2. Meaning of Science Communicated
3. Integration of Science
4. Accumulated Knowledge of Science
5. Relationships of Social, Technological and Scientific Issues

Cross-Cutting Expectations/Themes

Illustrate how knowledge, principles, and concepts connect one science subject to another.

- Energy/Matter
- Patterns of Change
- Systems and Interactions
- Stability
- Models

Examples of Content Standards and Benchmarks

Standard: Grades 9–12

Life Science--the diversity of organisms—the cell—heredity

(p. 24)

Benchmarks for this Standard

As a result of activities in grades 6–8, all students should develop an understanding of:

1. Structure and function in living systems
2. Reproduction and heredity
3. Regulation and behavior
4. Populations and ecosystems
5. Diversity and adaptation of organisms
6. Mechanisms of health and disease

Kentucky

Mathematics and Science Standards and Examples

Sources

Core Content for Mathematics Assessment (Draft, 1996)

Core Content for Science Assessment (Draft, 1996)

The Core Content materials lay out the connection between the assessment systems and the content areas defined in the curriculum document, *Transformations: Kentucky's Curriculum Framework* (1993). These are working drafts that propose to connect existing curriculum components in *Transformations* to KIRIS (state assessment system).

	CONTENT STANDARDS	BENCHMARKS/INDICATORS
Kentucky's Term	"Core Content Strands"	No term indicated
Kentucky's Definition	Connection between state assessment and content in state framework	No definition
Number	4 Mathematics, 3 Science	5-10 per strand
	Elementary, Middle, High	Elementary, Middle, High

Mathematical Standards

1. Number and Computation
2. Geometry and Measurement
3. Probability and Statistics
4. Algebraic Ideas and Algebra Related Topics

Science Standards

1. Physical Science
2. Life Science
3. Earth and Space Science

Cross-Cutting Expectations/Themes

Mathematics academic expectations are demonstrated through:

- Mathematical Procedures
- Mathematical Structure
- Change

Science academic expectations are demonstrated through:

- Science Process Skills
- Scientific Habits of Mind
- Critical Response Skills
- Manipulative Skills
- Communication Tools

Examples of Content Standards and Benchmarks

Standard: Middle Grades

Mathematics

Algebra Concepts

Algebra Skills

Relationships

(p. 6)

Benchmarks for this Standard

1. Variable, equation, inequality, algebraic expression
2. Functions through pictures, tables, graphs, rules, and algebraic notation
3. Rectangular (Cartesian) coordinate system/grid
4. Graphs of lines and tables
5. Simplify numerical and algebraic expressions.
6. Solve simple equations and inequalities.
7. Model equations and inequalities.
8. Use variables to describe numerical patterns.
9. Represent and use functions through tables, graphs, rules, and equations.
10. How tables, graphs, rules, and equations relate to each other
11. How the change in one variable affects the change in another variable

Standard: Middle Grades

Science

Structure and Function in Living Systems (example benchmarks in cells are listed)

1. Relation between structure and function
2. Unicellular; multicellular
3. Cell specialization and cooperation

Louisiana

Mathematics and Science Standards and Examples

Source

Louisiana Mathematics Framework (1995)

Louisiana Science Framework (1996)

The Frameworks were a collaborative effort of the Bureaus of Assessment and Curriculum, and they are expected to be used both to structure a new assessment system and to be the basis of continuing professional development sponsored by the state's SSI program (LASIP).

	CONTENT STANDARDS	BENCHMARKS/INDICATORS
Louisiana's Term	"Content Strands"	"Benchmarks"
Louisiana's Definition	Not defined	Broad statements of process or content used as a reference to develop curriculum and assist student progress (p. 13)
Number	6 Mathematics strands, 5 Science strands Apply to all grades	3-15 per strand PreK, K–4, 5–8, 9–12

Mathematics Standards

1. Number and Number Relations
2. Algebra
3. Measurement
4. Geometry
5. Discrete Math and Probability
6. Patterns, Relations, and Functions

Science Standards

1. Science as Inquiry
2. Physical Science
3. Life Science
4. Earth and Space Science
5. Science and the Environment

Cross-Cutting Expectations/Themes

Mathematics (Ref. NCTM, pp. 7-8)

- Problem Solving
- Numerical Intuition
- Mathematics Reasoning
- Connections
- Communication

Science

- Systems, Order, and Communication
- Evidence, Models, and Explanation
- Change, Constancy, and Measurement
- Form and Function

Section II argues for a new vision of science teaching and learning and lists broad categories of desired activities:

- Using Knowledge
- Constructing New Knowledge
- Reflecting on Knowledge

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Examples of Content Standards and Benchmarks

Standard: Grades 5–8

Mathematics

Algebra ... refers to informal explorations and understandings of symbolism. It is beneficial to introduce the algebraic terminology ... in the early grades ...

(p. 18)

Benchmarks for this Standard

1. Demonstrating a conceptual understanding of variables, expressions, equations and inequalities
2. Modeling and developing methods of solving equations and inequalities
3. Representing situations and number patterns with tables, graphs, and verbal and written statements while exploring the interrelationships of these representations
4. Analyzing tables and graphs to identify relationships exhibited by the data and making generalizations based on these relationships
5. Demonstrating the connectedness of algebra to the other strands and to real-life situations

Standard: Grades 5–8

Science

Structure and function in living systems

(p. 27)

1. Describing the observable components and functions of a cell
2. Comparing and contrasting the basic structures and functions of different types of cells including plants and animals
3. Describing the growth and development of several organisms
4. Describing the basic processes of photosynthesis and respiration and their importance to life
5. Describing ways that multicellular organisms get food and other matter into and out of cells
6. Describing and giving examples of noncommunicable diseases, and communicable diseases such as heat disease and chicken pox
7. Describing how the human body changes with age and list factors that affect the length and quality of life

Maine

Mathematics and Science Standards and Examples

Source

Maine's Curriculum Framework for Mathematics and Science (1995)

The Maine Framework includes an extensive rationale for change, a vision for the future, state standards, and guidance to carry the process forward, as one component of the state's systemic reform initiative, "Maine: A Community of Discovery." The framework includes standards for content, professional teachers, equity, and school and community.

[redacted]	CONTENT STANDARDS	BENCHMARKS/INDICATORS	[redacted]
Maine's Term	"Guiding Principles" and "Content Standards"	"Performance Indicators"	
Maine's Definition	Describe important strands or themes suggested by a guiding principle.	Specific indicators of what students should know and be able to do at each of four grade clusters to move toward achievement of the content standard and guiding principle.	
Number	7 Principles, 9 Mathematics and Science Standards; Apply to all grades	5-20+ per standard PreK-2, 3-5, 6-8, 9-12	

Mathematics and Science—Guiding Principles

Students:

1. Understand the nature of mathematics and science.
2. Communicate effectively in mathematics and science.
3. Reason effectively in mathematics and science.
4. Are problem solvers in mathematics and science
5. Understand their roles in the natural world.
6. Understand historical and societal implications of mathematics and science.
7. Attain and apply essential knowledge and skills of mathematics and science.

Mathematics Standards

Students understand and demonstrate/apply:

1. Number sense
2. Computation skills
3. Data analysis
4. Probability
5. Geometry
6. Measurement skills
7. Patterns, relationships, and functions
8. Algebraic concepts
9. Concepts in discrete mathematics

Science Standards

Students will understand:

1. Similarities within the diversity of all living things
2. How living things depend on one another and nonliving aspects of the environment
3. Cells are the basic units of life that can reproduce themselves.
4. The basis for life and that all living things change over time
5. The structure of matter and the changes it can undergo
6. The earth and the processes that change it
7. The universe, how humans have learned about it and the principles upon which it operates
8. The concepts of energy
9. The motion of objects and how forces change that motion

Examples of Content Standards and Benchmarks

Standard: Grades 6–8

Mathematics

Students understand and apply algebraic concepts

(pp. II-61)

Benchmarks for this Standard

1. Use the concepts of variable, expressions, and equation.
2. Solve linear equations using concrete, informal and formal methods.
3. Investigate inequalities and nonlinear equations.
4. Analyze tables and graphs to identify properties and relationships.
5. Use graphs to represent equations in two variables.
6. Interpret graphs that represent practical situations.

Standard: Grades 6–8

Science

Students understand that cells are the basic units of life that can reproduce themselves (pp. II-66)

1. Compare and contrast human organ systems with those of other species.
2. Know that different cells have different functions in multi-celled organisms.
3. Understand that cells function individually and as components of systems.
4. Prepare and study microscope slides of plant and animal cells.
5. Describe the structure and function of major organs in human systems.
6. Describe ways diseases are caused and are transmitted and ways in which they can be prevented.

Massachusetts

Mathematics and Science Standards and Examples

Source

The Massachusetts Curriculum Framework: Achieving Mathematical Power (1995)

The Massachusetts Science and Technology Curriculum Framework: Owning the Questions Through Science and Technology Education (1995)

The math and science frameworks are interconnected and intraconnected documents, and they build on a set of "common chapters" that establish the philosophy and foundation of the state's standards-based program in core content areas. Both mathematics and science frameworks include extended discussions of philosophy, pedagogy, and model practice; they offer resources; and they set very high standards for establishing a thinking-based program that serves all students, especially those previously under-represented in mathematics and sciences.

	CONTENT STANDARDS	BENCHMARKS/INDICATORS
Massachusetts' Term	"Strands"	"Learning Standards"
Massachusetts's Definition	"... describe[s] the content and skills that are woven through the student's experiences with the discipline, PreK–12." Specific content expectations are defined in the Domains of Science strand in science and the Content strand in mathematics.	"... describe[s] specifically what students should know and be able to do at the end of grades four, eight, ten, and twelve." Learning standards include example "student learnings" that illustrate the indicator of learning.
Number	4 Mathematics, 4 Science Apply to all grades	4-8 per strand, Mathematics 8-12 per strand, Science PreK–4, 5–8, 9–10, 11–12

Mathematics Standards

1. Number Sense
2. Patterns, Relations, and Functions
3. Geometry and Measurement
4. Statistics and Probability

Science Standards

1. Inquiry
2. Domains of Science: Physical, Life, Earth and Space
3. Technology
4. Science, Technology, and Human Affairs

Cross-Cutting Expectations/Themes

Mathematics:
Guiding Principles (see original for extended phrases)

- Students explore mathematical ideas.
- All students have access to high quality mathematics programs.
- Mathematics learning is a lifelong process.
- Mathematics instruction both connects with other disciplines and moves toward integration of mathematical domains.
- Working together in teams and groups enhances mathematical learning.
- Technology is an essential tool for effective mathematics education.
- Mathematics assessment is a multifaceted tool that monitors student performance, improves instruction, enhances learning, and encourages student self-reflection.

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Cross-Cutting Expectations/Themes (cont'd)

Science:
Guiding Principles of Science and Technology

- Build on students' curiosity and intuition
- Investigation and problem solving
- Students learn best in an environment that acknowledges, respects and accommodates each learner's background, individuality, and gender.
- Connect with other disciplines and have an integral relationship with mathematics.
- All students in a comprehensive science and technology education program PreK–12. Pre K–10 course work should integrate all sciences every year.
- Science and technology study differentiated in grades 11 and 12 based on students' interests and career goals
- Communication and collaboration essential
- Access to the expertise of others needed for interdisciplinary approach

Examples of Content Standards and Benchmarks

Standards: Grades 5–8

Mathematics

Algebra: Students engage in problem solving, communicating, reasoning, and connecting to:

(p. 61)

Benchmarks for this Standard

1. Understand and apply the concepts of variables, expression, and equation.
2. Represent situations and number patterns with tables, graphs, verbal rules, and equations and explore the interrelationships of these representations.
3. Analyze tables and graphs to identify properties and relationships.
4. Demonstrate an ability to solve linear equations using concrete, informal, and formal methods.
5. Describe the strategies used to explore inequalities and nonlinear equations.
6. Apply algebraic methods to solve a variety of real-world and theoretical problems.
7. Construct expressions or equations that model problems.
8. Explore and describe a variety of ways to solve equations, including hands-on activities, trial and error, and numerical analyses.
9. Know and apply algebraic procedures for solving equations and inequalities.

Standards: Grades 5–8

Science

Life Science: Characteristics of Organisms

(p. 62)

1. Identify the cell as the basic unit of life and the smallest unit that can reproduce itself.
2. Explore and describe an understanding that plants, animals, fungi, and various types of microorganisms are major categories of living organisms.
3. Observe and explain that in single cells there are common features that all cells have as well as differences that determine their function.
4. Investigate and illustrate evidence that cell replication results not only in the multiplication of individual cells, but also in the growth and repair of multi-cellular organisms.
5. Present data to illustrate that all organisms, whether single or multi-cellular, exhibit the same life processes, including growth, reproduction and the exchange of materials and energy with their environment.
6. Describe ways that cells can differ in multi-cellular organisms, assuming different appearances and carrying out specialized functions.
7. Investigate and explain that complex multi-cellular organisms are interacting systems of cells, tissues, and organs that fulfill life processes through mechanical, electrical, and chemical means, including procuring or manufacturing food, and breathing and respiration.

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Michigan

Mathematics and Science Standards and Examples

Source

Michigan Curriculum Framework (Draft 1996)

The Framework brings together the work of individual content area projects to present a unified view of curriculum, one which addresses the educational needs of the whole learner. The goal of the curriculum framework is to improve student achievement by aligning classroom instruction with core curriculum content standards and national content standards. It is designed to be used as a process for the decision-making that guides continuous school improvement. It describes curriculum, instruction, and assessment and focuses on improving program quality by aligning all the processes that affect a student's achievement of rigorous content standards.

	CONTENT STANDARDS	BENCHMARKS/INDICATORS
Michigan's Term	"Content Standards"	"Benchmarks"
Michigan's Definition	Descriptions of what students should know and be able to do in subject areas, English language, arts, social studies, mathematics, and science	Designed to be examples of high standards at the developmental stage of each grade cluster. They provide structure for instructional design that should be adapted to the rates and modes of student learning.
Number	15 Mathematics, 15 Science	5-7 per standard
	Standards apply to all grade levels	Elementary, Middle, High

Mathematics Standards

1. Patterns, relationships, and functions
2. Variability and change
3. Geometry and measurement: shape and shape relationships
4. Geometry and measurement: position
5. Measurement
6. Data analysis: collection, organization, and presentation of data
7. Data analysis: description and interpretation
8. Data analysis: inference and prediction
9. Number sense and numeration: concepts and properties of numbers
10. Number sense and numeration: representation and uses of numbers
11. Number sense and numeration: number relationships
12. Numerical and algebraic operations and analytical thinking: operation and properties
13. Numerical and algebraic operations and analytical thinking: algebraic and analytical thinking
14. Probability
15. Discrete mathematics

Science Standards

1. Construct new knowledge.
2. Reflect on knowledge.
3. Use scientific knowledge to:
   - Look at cells
   - Examine living things
   - Study heredity
   - Study evolution
   - Study ecosystems
4. Use scientific knowledge from the physical sciences in real world contexts to study:
   - Matter and energy
   - Changes in matter
   - Motion in objects
   - Waves and vibrations
5. Use scientific knowledge from the earth and space sciences in real world contexts, such as the:
   - Geosphere
   - Hydrosphere
   - Atmosphere and weather
   - Solar system, galaxy and universe

Cross-Cutting Expectations/Themes

Each content standard is cross-referenced with complementary standards in arts education, career and employability skills, health education, life management education, physical education, technology, and world languages.

Four fundamental emphases to be integrated throughout the curriculum:

- Learning as active construction of meaning
- Learning as cultural and social inquiry
- Learning as meaningful application of knowledge
- Learning as attitudes and dispositions

Example of Content Standards and Benchmarks

Standard: Middle Grades

Mathematics

Students analyze problems to determine an appropriate process for solution, and use algebraic notations to model or represent problems.

Benchmarks for this Standard

Solve linear equalities and inequalities using algebraic and geometric methods, and use the context of the problem to interpret and explain their solutions.

Standard: Middle Grades

Science

All students will apply an understanding of cells to the functioning of multi-cellular organisms, and explain how cells grow, develop, and reproduce.

1. Describe similarities/differences between single-celled and multicellular organisms.
2. Explain why specialized cells are needed by plants and animals.
3. Explain how cells use food as a source of energy.

Mississippi

Mathematics and Science Standards and Examples

Source (Mathematics)

Mathematics: *Mississippi Mathematics Curriculum Structure (1995)*

The document contains six interrelated content strands that pervade kindergarten through grade twelve. For each strand, there are goals and objectives articulated at each grade level. Objectives are not intended to be taught in any specific order. A related document entitled Mississippi Mathematics Process Guide is designed to assist teachers with models of instructional practice, activities, and instructional talks related to each strand of the standards.

Science: *Mississippi Science Framework (1996)*

Strands are integrated into each grade and course. General overview for each grade (1-8) and course title (from science to chemistry to zoology). Each description includes competencies that are to be taught to all students as well as sample objectives to use in devising local objectives.

MATHEMATICS	CONTENT STANDARDS	BENCHMARKS/INDICATORS
Mississippi's Term	"Content Strands"	"Objectives"
Mississippi's Definition	Six interrelated strands to pervade K–12 math education	Stress the importance of active student involvement in applying mathematics to real world problem solving, using manipulative materials and modeling concepts.
Number	Six strands K–12	4-5 per strand per grade K–8, per course 9–12
SCIENCE	**CONTENT STANDARDS**	**BENCHMARKS/INDICATORS**
Mississippi's Term	"Strands"	"Competencies"
Mississippi's Definition	Integrated information into each grade and course	General concepts or performances that are required to be taught to all students by the school districts.
Number	Four strands Applicable to 1–8 and secondary courses	15 per strand by grade K–8, and 19 specific secondary courses

Mathematics Standards

1. Number Sense/Numeration/Operations
2. Patterns/Relations/Functions
3. Algebra
4. Measurement
5. Geometry
6. Statistics/Probability

Science Standards

1. Life science
2. Earth science
3. Physical science
4. Science skills

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Example of Content Standards and Benchmarks

Standard: Grade 6

Mathematics: Algebra

The goal of Algebra is for students to understand the language of algebra and apply concepts of polynomials, equations, and inequalities to real life problem-solving situations.

(p. 48)

Benchmarks for this Standard

1. Use language of algebra to communicate, in writing or by example, the following concepts: variable, term, constant, coefficient, exponent, base, factor, monomial, polynomial, linear expression/equation/inequality, quadratic expression/equation/inequality.
2. Add and subtract polynomial expressions.
3. Multiply, divide, and factor polynomial expressions, applying the laws of exponents; apply exponential ideas by solving problems involving rates of growth.
4. Write problem situations to accompany linear algebraic expressions and equations; write linear algebraic expressions and equations that describe problem situations.
5. Solve equations containing rational coefficients; include real life problem-solving situations; use manipulative materials and calculators/computers where appropriate.
6. Solve inequalities containing rational coefficients; include real life problem-solving situations; use manipulative materials and calculators/computers where appropriate.
7. Solve equations for a single variable in terms of other variables.
8. Investigate solutions to quadratic equations through the use of factoring, the quadratic formula, and calculator or computer applications; apply such concepts to real life situations.
9. Solve absolute value equations and inequalities in one variable; include the use of number line representations.

Standard: Grade 6

Science

Life science and Science skills

(p. 89)

Benchmarks for this Standard

1. Describe the basic parts of a plant cell and the function of each part
2. Describe the basic parts of an animal cell and describe the function of each part
3. Identify DNA (chromosomes) as the material that determines inheritance patterns
4. Define the concepts of dominant and recessive traits.

Missouri

Mathematics and Science Standards and Examples

Source

Mathematics: *Missouri Math Curriculum Framework (1996)*

The *Framework* provides a "road map" for developing mathematics curricula. It briefly describes suggested practices for teaching and learning mathematics. The body of the document consists of four process strands and six content strands. The process strands are intended to be cross-cutting themes incorporated throughout the curriculum, and the content strands, each followed by "To Know" and "To Do" statements and sample learning activities, are a guide for the content that should be taught to all students in grades K–12.

Science: *Missouri Science Curriculum Framework (1996)*

The *Framework* is based on eight strands. Scientific inquiry and scientific relevance, the first two strands, can be incorporated into all the other strands. The six remaining standards focus on content areas. The strands are derived from the Missouri Show-Me Standards and designed to be user friendly to curriculum writers using the framework as a guide to develop local science curricula. By applying the strands across all grade levels, fundamental content will be introduced in the lower grades, reinforced, and extended in an upward spiral at successive grade levels.

MATHEMATICS	CONTENT STANDARDS	BENCHMARKS/INDICATORS
Missouri's Term	"Strands"	"To Know Statements"
Missouri's Definition	Four "process" strands that define major areas of emphasis with respect to the teaching of mathematics, six "content strands" which define the mathematical knowledge that should be taught using the four process strands	—
Number	10 strands apply to all grade levels	4 per strand K–4, 5–8, 9–12

SCIENCE	CONTENT STANDARDS	BENCHMARKS/INDICATORS
Missouri's Term	"Content Strands"	"What All Students Should Know"
Missouri's Definition	Organizers that provide the foundations for understanding and applying scientific knowledge	No definition is provided, but the meaning is evident from the name.
Number	8 strands	All eight content strands apply to grade levels K–12.
	5 per strand	*Note:* The strands are further divided into sub-categories. Sub-categories include benchmarks separated into grade level clusters K-4, 5-8, 9-12.

Mathematics Standards

1. Problem Solving
2. Communication
3. Reasoning
4. Connections
5. Number Sense
6. Geometric and Spatial Sense
7. Data Analysis/Probability and Statistics
8. Patterns and Relationships
9. Mathematical Systems and Number Theory
10. Discrete Mathematics

Science Standards

1. Scientific Inquiry
   - Processes
   - Investigations
2. Scientific Relevance
   - Nature of technology
   - Science as a human endeavor
   - Historical perspective
3. Matter and Energy
   - Properties, characteristics and structure of matter
   - Characteristics, forms and sources of energy
   - Interactions of matter and energy
4. Force, Motion and Mechanical Energy
   - Relative motion
   - Types and properties of forces and motion
   - Interactions of forces and motion
5. The Universe
   - Characteristics of the solar system
   - Motion of the solar system
   - Technology
6. Earth Systems
   - Physical systems
   - Processes of systems
7. Living Systems
   - Structure/function/characteristics of living organisms
   - Life processes
   - Diversity/interdependence
   - Reproduction
   - Interactions of forces and motion
8. Ecology
   - Interactions of ecosystems
   - Changes in ecosystems

Cross-Cutting Expectations/Themes

- Systems
- Models
- Consistency and patterns of change
- Scale

Examples of Content Standards and Benchmarks

Standard: Grades 5–8

Mathematics

Patterns and Relationships:

Representing and analyzing patterns and relationships allow for the development of understanding the connections between and among algebra, geometry, trigonometry, functions and change relationships.

(p. 69)

Benchmarks for this Standard

By the end of grade 8, all students should know that:

1. Mathematical ideas may be represented by visual models.
2. Mathematical symbols can be used to represent real-world situations.
3. Patterns and relationships can be represented in a variety of ways.
4. Information can be organized to look for a pattern or relationship.
5. Patterns can be geometric and/or numeric.

Standard: Grades 5–8

Science

Living Systems:

Understanding and appreciating the Diversity of Life comes from students' ability to see the patterns of similarity and differences that permeate the living world. The living environment consists of millions (perhaps tens of millions) of different types of organisms, all of which carry out the same basic functions that have maintained life for millions of years. The information required to carry out the life functions is encoded in chemicals in the nuclei of cells and is passed from generation to generation. A complex interplay between variations in the genetic code and environmental factors results, over time, in changes in living organisms.

(p. 70)

Benchmarks for this Standard

By the end of grade 8, all students should know that:

1. Organisms can be classified into five kingdoms based on similarities and differences.
2. The basic unit of life is the cell. Different cells are specialized to perform various tasks. Cells of similar shape and function are organized into groups.
3. In living systems, from cells to biosphere, components interact within a hierarchy of organization.
4. Cells contain a set of structures called organelles that control the various functions of the cell.

New Hampshire

Mathematics and Science Standards and Examples

Source

New Hampshire K–12 Science Curriculum Framework (1995)

New Hampshire K–12 Mathematics Curriculum Framework (1995)

The frameworks are very brief documents, approximately 30 pages that present the content and proficiency standards in an outline form. In addition, there are three supplementary documents that further detail the proficiency standards, rationale, and pedagogy, and they provide vignettes, examples, and model activities. Each addendum is approximately 55 pages long.

	CONTENT STANDARDS	BENCHMARKS/INDICATORS
New Hampshire's Term	"Broad Goals"	"Curriculum Standards"
New Hampshire's Definition	General expectations of what all New Hampshire students are expected to know and be able to do	The Curriculum Standards identify the scope of the content recommended for grades K–3, 4–6, and 7–12.
Number	8 Mathematics, 6 Science K–12	6-8 per goal K–3, 4–6, and 7–12.

Mathematics Standards

1. Problem Solving and Reasoning
2. Communications and Connections
3. Numbers, Numeration, Operations, and Number Theory
4. Geometry, Measurement, and Trigonometry
5. Data Analysis, Statistics, and Probability
6. Functions, Relations and Algebra
7. Mathematics of Change
8. Discrete Mathematics

Science Standards

1. Science as Inquiry
2. Science, Technology, and Society
3. Life Science
4. Earth/Space Science
5. Physical Science
6. Unifying Themes and Concepts

Cross-Cutting Expectations/Themes

Mathematics:

None indicated

Science:

"The scientific community has identified several themes and concepts which allow us to integrate scientific knowledge for greater understanding. Those most often mentioned are: scale and structure, patterns and change, evolution, constancy and equilibrium, cause and effect, models, energy, and systems and interactions."

Examples of Content Standards and Benchmarks

Standard: Grade 6

Science

Life Science: Students will demonstrate an increasing ability to understand fundamental structures, functions, and mechanisms of inheritance found in microorganisms, fungi, protists, plants, and animals.

(p. 18)

Benchmarks for this Standard

Students will be able to:

1. Describe similarities and differences between single celled and multicellular organisms, e.g. cell structures.
2. Identify the major anatomical features of plants and animals, and the major function of each.
3. Observe and describe major characteristics of various life forms, e.g. microorganisms, fungi, protists, plants and animals.
4. Compare and contrast life processes in plants and animals, e.g. growth and development, nutrition, reproduction, etc.

Standard: Grade 6

Mathematics

Functions, Relations and Algebra: Students will use algebraic concepts and processes to represent situations that involve variable quantities with expressions, equations, inequalities, matrices and graphs.

(p. 24)

Benchmarks for this Standard

Students will be able to:

1. Solve linear equations by using concrete materials, tables, or graphs.
2. Represent situations and number patterns with concrete materials, tables, graphs, verbal rules, and standard algebraic notation.
3. Understand the use of literal variables, expressions, equations, and inequalities.
4. Analyze tables and graphs to identify algebraic relationships.

New Jersey

Mathematics and Science Standards and Examples

Source

New Jersey Core Curriculum Content Standards (1996)

Standards were developed with Eisenhower funding. In 1992-93, panels of educators, business people, and other citizens developed preliminary draft standards in the seven academic areas and career education. During 1995, similar working groups built on these standards and engaged in a public review process. A related document, N.J. Math Curriculum Framework (January, 1995), expands on standards, describes procedures and strategies for implementation, gives guidance to districts, and provides illustrative vignettes.

	CONTENT STANDARDS	BENCHMARKS/INDICATORS
New Jersey's Term	"Standards"	"Cumulative Progress Indicator"
New Jersey's Definition	... what all students should know and be able to do upon completion of a 13-year public education	What students need to know and be able to do by the end of grades 4, 8, and 11–12
Number	18 Mathematics, 13 Science Standards apply to all grade levels.	4-8 per standard Grades: 4, 8, 11–12

Mathematics Standards

Learning Environment Standards

1. All students will demonstrate high levels of mathematical thought and will have opportunities for further study in mathematics at all grade levels.
2. All students will embody the concept that engagement in mathematics is essential.
3. All students will be evaluated using a diversity of assessment tools and strategies.

Math Content: All students will develop ability/understanding through experiences:

1. Pose and solve mathematical problems.
2. Communicate mathematically.
3. Connect mathematics to other learning
4. Reasoning ability.
5. Use calculators, computers, manipulatives.
6. Develop number sense.
7. Develop spatial sense.
8. Numerical operations
9. Measurement and systems of measurement
10. Estimation
11. Patterns, relationships, and function
12. Probability and statistics, and data
13. Algebraic concepts and processes
14. Discrete mathematics
15. Conceptual building blocks of calculus

Science Standards

All students will develop or gain understanding:

1. Problem-solving, decision-making and inquiry skills
2. Contributions of various cultures
3. Safety in the classroom
4. Technology as an application
5. Mathematics as a tool for problem-solving
6. Structure, characteristics and basic needs of organisms
7. Diversity of life
8. Structures and behavior of matter
9. Natural laws of motion, force, energy
10. Structure, dynamics and geophysical systems of the earth
11. Origin, evolution and structure of the universe
12. Environment as a system
13. Systems of interacting components

Cross-Cutting Expectations/Themes

"Cross-Content Workplace Readiness Standards" that apply to all content areas (p. 1):

All students will:

- Develop career planning and workplace readiness skills.
- Use technology, information, and other tools.
- Use critical thinking, decision-making, and problem-solving skills.
- Demonstrate self-management skills.
- Apply safety principles.

Example of Content Standards and Benchmarks

Standard: Grade 8

Mathematics

Content standard 4.13: All students will develop an understanding of algebraic concepts and processes and will use them to represent and analyze relationships among variable quantities and to solve problems.

(pp. 4-33)

Benchmarks for this Standard

1. Solve simple linear equations using concrete, informal and graphical methods, as well as appropriate paper and pencil techniques.
2. Explore linear equations through the use of calculators, computers, and other technology.

Standard: Grade 8

Science

Content Standard 5.6: All students will gain an understanding of the structure, characteristics, and basic needs of organisms.

(p. 5-11)

Benchmarks for this Standard

Building upon the knowledge and skills gained in the preceding grades, by the end of grade 8 students:

1. Describe and give examples of the major categories of living organisms and of the characteristics shared by organisms .
2. Recognize that complex multicellular organisms are interacting systems of cells, tissues, and organs .
3. Identify and describe the structure and function of cell parts .
4. Explain how organisms are affected by different components of an ecosystem and the flow of energy through it.
5. Illustrate and explain life cycles of organisms.

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New Mexico

Mathematics and Science Standards and Examples

Source

New Mexico Mathematics and Science Content Standards with Benchmarks (1996)

Committees of teachers, university faculty and business people formed the standards development committees. Funding from the state department of education, Eisenhower funds, and SSI supported the standards development effort. According to state department staff, the standards are designed to be used by districts "to create, deliver, and assess challenging curriculum and improve student learning." The state standards will be tied directly to each district's Educational Plan for Student Success (EPSS), a long-range strategic plan each student must develop through a comprehensive self-study.

	CONTENT STANDARDS	BENCHMARKS/INDICATORS
New Mexico's Term	"Content Standards"	"Benchmark"
New Mexico's Definition	Not defined	Not defined
Number	5 Mathematics, 8 Science, plus 3-5 sub-categories per main standard K–12	3-4 per standard K–4, 5–8, 9–12

Mathematics Standards

1. Unifying Concepts and Processes
2. Number and Operation Concepts
3. Geometry and Measurement Concepts
4. Statistics and Probability Concepts
5. Functions and Algebra Concepts

Science Standards

1. Unifying Concepts and Processes
2. Science as Inquiry
3. Physical Science
4. Life Science
5. Earth and Space Science
6. Science and Technology
7. Science in Personal and Social Perspectives
8. History and Nature of Science

Cross-Cutting Expectations/Themes

Mathematics

Unifying concepts and processes:

- Problem solving
- Communication
- Reasoning
- Connections

Science

Unifying concepts and processes:

- Systems, order, and organization
- Evidence, models, and explanation
- Constancy, change, and measurement
- Evolution and equilibrium
- Form and Function

Examples of Content Standards and Benchmarks

Standard: Grades 5–8

Mathematics

Functions and Algebra Concepts; 5–8 Algebra

Benchmarks for this Standard

1. Understand the concepts of variables, expression and equation.
2. Represent situations and number patterns with tables, graphs, verbal rules, and equations, and explore the interrelationships of these representations.
3. Analyze tables and graphs to identify properties and relationships.
4. Develop confidence in solving linear equations using concrete, informal and formal methods.
5. Investigate inequalities and nonlinear equations informally.
6. Apply algebraic methods to solve a variety of real-world and mathematical problems.

Standard: Grades 5–8

Science

Life Science: Structure and Function of Living Systems

Benchmarks for this Standard

1. Living systems at all levels of organizations demonstrate complementary relationships between structure and function.
2. All organisms are composed of cells, the fundamental unit of life.
3. Cells carry on the many functions needed to sustain life.
4. Cells grow and divide, thereby producing more cells.
5. Cells take in nutrients, which they use to power the work that cells do and to make the materials that a cell or an organism needs.
6. Disease represents a breakdown in structures or functions of an organism.

New York

Mathematics and Science Standards and Examples

Source

New York Learning Standards for Math, Science, and Technology (1996)

The document introduces seven standards and forty pages containing examples of student work demonstrating various levels of success in achieving proficiency in work related to the standards. Each standard is followed by key ideas, performance indicators, and sample tasks. The components of each standard are separated into three grade level clusters (elementary, intermediate, and commencement).

	CONTENT STANDARDS	BENCHMARKS/INDICATORS
New York's Term	"Learning Standards"	"Performance Indicators"
New York's Definition	The document does not include a definition of content standards.	Indicators of what students should be able to do related to the key ideas articulated with each standard
Number	7 Learning standards apply to all grade levels	2-6 per standard Elementary, Intermediate, Commencement

Standards

1. Students will use mathematical analysis, scientific inquiry, and engineering design, as appropriate, to pose questions, seek answers, and develop solutions.
2. Students will access, generate, process, and transfer information using appropriate technologies.
3. Students will understand mathematics and become mathematically confident by communicating and reasoning mathematically, by applying mathematics in real-world settings, and by solving problems through the integrated study of number systems, geometry, algebra, data analysis, probability, and trigonometry.
4. Students will understand and apply scientific concepts, principles, and theories pertaining to the physical setting and living environment and recognize the historical development of ideas in science.
5. Students will apply technological knowledge and skills to design, construct, use, and evaluate products and systems to satisfy human and environmental needs.
6. Students will understand the relationships and common themes that connect mathematics, science, and technology and apply the themes to these and other areas of learning.
7. Students will apply the knowledge and thinking skills of mathematics, science, and technology to address real-life problems and make informed decisions.

Cross-Cutting Expectations/Themes

Standards six and seven are cross-cutting themes on Interconnectedness: Common Themes and Skills Interdisciplinary Problem Solving.

Examples of Content Standards and Benchmarks

Standard: Intermediate

Mathematics

Students will understand mathematics and become mathematically confident by communicating and reasoning mathematically, by applying mathematics in real-world settings, and by solving problems through the integrated study of number systems, geometry, algebra, data analysis, probability, and trigonometry.

(p. 21)

Benchmarks for this Standard

1. Recognize, describe, and generalize a wide variety of patterns and functions.
2. Describe and represent patterns and functional relationships using tables, charts and graphs, algebraic expressions, rules, and verbal descriptions.
3. Develop methods to solve basic linear and quadratic equations.
4. Develop an understanding of functions and functional relationships: that a change in one quantity results in change in another.
5. Verify results of substituting variables.
6. Apply the concept of similarity in relevant situations.

Standard: Intermediate

Science

Students will understand and apply scientific concepts, principles, and theories pertaining to the physical setting and living environment and recognize the historical development of ideas in science.

Benchmarks for this Standard

1. Compare and contrast the parts of plants, animals and one-celled organisms.
2. Explain the functioning of the major human organ systems and their interactions.
3. Describe sexual and asexual mechanisms for passing genetic materials from generation to generation.
4. Describe simple mechanisms related to the inheritance of some physical traits in offspring.
5. Describe sources of variation in organisms and their structures and relate the variations to survival.
6. Describe factors responsible for competition within species and the significance of that competition.
7. Observe and describe cell division at the microscopic level and its macroscopic effects.
8. Compare the way a variety of living specimens carry out basic life functions and maintain dynamic equilibrium.

North Carolina

Science Standards and Examples

Source

North Carolina Standard Course of Study, Competency-based Curriculum: Teacher Handbook, Science K–12 (1994)

The North Carolina frameworks were originally conceptualized in the late 1980's and have been revised and updated several times. They are provided within a series of subject-specific "Teacher Handbooks," loose-leaf notebooks that are periodically supplemented and revised. Within the handbook are a "Standard Course of Study" and competency objectives for each grade.

	CONTENT STANDARDS	BENCHMARKS/INDICATORS
North Carolina's Term	"Competency Goals"	"Objectives"
North Carolina's Definition	No definition given	No definition is given; they are specific markers for achieving the competency goals within grade level and subject.
Number	5 goals K–12 plus 1–4 per grade/course	5-8 per standard K–5, 6–8, 9–12

Science Standards

The "program goals" of science cut across grade levels. They are intended to "permeate the curriculum" and form the source of all science objectives:

1. Understand the nature of science.
2. Become proficient in using science process skills to solve problems and make decisions.
3. Develop skills to manipulate and/or operate science equipment.
4. Develop responsible attitudes toward the environment, science, technology, and society.
5. Understand basic scientific concepts and principles.

Grades K – 8 Goals:

- Grade K: Student and his/her world
- Grade 1: Living and nonliving objects
- Grade 2: Changes within the world
- Grade 3: Patterns and systems
- Grade 4: Analyzing systems
- Grade 5: Energy Concepts
- Grade 6: Patterns and cycles in the natural world
- Grade 7: Systems and diversity
- Grade 8: Change within systems

High School Science Courses

Biology Goals:

- Chemical and physical basis of life
- Continuity of life
- Ecology

Chemistry Goals:

- Properties of solutions
- Regularities in chemistry
- Changes in chemistry
- Models in chemistry

Earth Science Goals:

- Location and mapping
- Geology
- Meteorology
- Oceanography
- Astronomy
- Natural resources and environment

Physical Science Goals:

- Sound, light, and heat
- Chemistry
- Mechanics
- Electricity and magnetism
- Energy

High School Science Courses (cont'd)

Physics Goals:

- Basic mechanics
- Thermodynamics
- Wave motion
- Electricity and magnetism

Cross-Cutting Expectations/Themes

Science concepts are to be presented under three general divisions of science: earth science, life science, and physical science. Themes to be emphasized:

- Matter
- Motion
- Energy
- Time
- Forces
- Space

Examples of Content Standards and Benchmarks

Standard: Grade 7

The learner will construct an understanding of science concepts through systems and diversity.

(p. 97)

Benchmarks for this Standard

1. Investigate the general properties and interactions of matter.
2. Investigate the interaction of social energy with the atmosphere and its effect on weather systems, seasons, and climates.
3. Investigate the basic components of motion.
4. Explore forms of energy and energy transformation in natural and people-made systems.
5. Explore the cell and cellular processes.

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Ohio

Science Standards and Examples

Source

Ohio Model Competency Based Science Program (1994)

This framework is developed in response to specific legislation requiring the development of learning objectives. Designed as a resource and technical guide to assist curriculum development, this document is viewed as a "model" for implementing Ohio's competency based program (CBE). It is a comprehensive document, including some unusual features such as extensive appendices of vignettes, recommended materials and equipment, health and safety requirements, etc. Both curriculum development and assessment guidance are detailed.

Ohio's Term	"Instructional Strands"	"Instructional Objective"
Ohio's Definition	The Ohio model establishes "learner outcomes," statements of what students should know and be able to do as they move through the school system; they include acquiring, processing, and extending scientific knowledge (p. 109).	"Instructional objectives are statements of the results expected of the learner following appropriate learner activities (p. 109)...." "Instructional objectives should be tailored to match the units of study determined by each grade level" (p. 16).
Number	4 strands All grade levels	2-10 objectives in each strand By grade

Science Standards

1. Scientific Inquiry—the desired technical skills and abilities
2. Scientific Knowledge—the big ideas of science to be studied
3. Conditions for Learning Science—strategies and activities for learning
4. Applications for Science Learning—ideas for how learners may use their learning

Cross-Cutting Expectations/Themes

- Science is for all students.
- Science content must actively engage learners.
- Science programs should be articulated, preK–12.
- Science content should be grounded in, and connect, the three domains of science in physical, living, and earth/space systems.
- Science programs must adequately reflect all four instructional strands.
- Science instructional and performance objectives should emphasize higher order thinking skills and complex performances.

Examples of Content Standards and Benchmarks

Standard: Grade 8

Scientific Knowledge

(p. 43)

Benchmarks for this Standard

1. Investigate composition and level of organization of objects and organisms (e.g., rocks, minerals, compounds, and elements; organisms, systems, tissues, and cells).
2. Investigate patterns in nature (e.g., symmetry, reflected and refracted light, life cycles, harmonic motion).
3. Investigate the heritability of attributes and the maintenance of diversity through a variety of reproductive strategies.
4. Investigate models of macro-molecular structures and the physical and biological implications of these structures (e.g., enzymes, DNA, hemoglobin, polymers).

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Oregon

Mathematics and Science Standards and Examples

Source

Oregon Common Curriculum Goals, Content Standards, and Benchmarks (1996)

The Common Curriculum Goals includes content standards in major content areas taught (English, mathematics, science, social sciences, second languages, the arts, health, physical education, technology systems, and essential learning skills). Performance Standard: Grades 3, 5, 8, 10 (1996) includes a list of phrases that suggest performance standards for reading/literature, mathematics, and writing, sample items for a few selected areas and scoring rubrics.

	CONTENT STANDARDS	BENCHMARKS/INDICATORS
Oregon's Term	"Content Standards"	"Benchmarks"
Oregon's Definition	... describe the core knowledge and skills required for the Certificates of Initial and Advanced Mastery ... the subset of the Common Curriculum Goals that will be assessed statewide.	None provided
Number	10 Mathematics, 8 Science per level: grades 3, 5, 8, 10	1-3 per standard 3, 5, 8, 10

Mathematics Standards

1. Computation
2. Estimation
3. Numbers and Algorithms
4. Measurement
5. Statistics and Probability
6. Algebra
7. Geometry
8. Mathematical Problem Solving
9. Communicate Reasoning
10. Interpret Reasonableness

Science Standards

1. Unifying Concepts and Processes
2. Physical Science
3. Life Science
4. Earth and Space Science
5. Scientific Inquiry
6. History and Nature of Science
7. Science and Technology
8. Science in Personal and Social Perspective

Example of Content Standards and Benchmarks

Standards: Grade 8

Mathematics

Algebra: Patterns, Functions, and Operations

(p. 17)

Benchmarks for this Standard

Investigate and solve linear and nonlinear equations and inequalities, using concrete, informal, and formal methods.

Use patterns, functions, and algebraic operations to represent and solve problems.

Science

Life Science:

Organisms: Describe the structure and function of cells and their molecular components.

(p. 22)

Benchmarks for this Standard

Describe and explain the structure and functions of an organism in terms of organ systems, organic tissues, and cells.

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Pennsylvania

Mathematics and Science Standards and Examples

Source

Mathematics: *Pennsylvania Mathematics Curriculum Framework (1994)*

The framework briefly introduces the evolving changes in mathematics curriculum and instruction and then defines standards in the form of two matrices associated with the four grade-level clusters. The matrices specify: (a) student learning outcomes and indicators, (b) instructional and assessment activities associated with the outcomes.

Science: *Pennsylvania Science and Technology Framework (1994)*

This is a comprehensive outline for redesigning science and technology curriculum in Pennsylvania. It includes a comprehensive rationale, linked to the national reform agenda, and a specific vision for the state. The curriculum design section lays out information to describe philosophic approaches, cross-cutting themes, learning opportunities, and assessment.

MATHEMATICS	CONTENT STANDARDS	BENCHMARKS/INDICATORS
Pennsylvania's Term	"Learning Outcomes"	"Outcome Indicators"
Pennsylvania's Definition	None provided	None provided
Number	7 K–12 Middle level, High level	1-4 per standard Primary, Intermediate, (grade equivalents are not defined.)

SCIENCE	CONTENT STANDARDS	BENCHMARKS/INDICATORS
Pennsylvania's Term	"Learning Outcomes"	"Standards"
Pennsylvania's Definition	None provided	Standards "may be used to assess student progress toward demonstrating attainment of the desired outcomes of learning ..."
Number	8 K–12	2-4 per standard per level Primary (grade 3), Intermediate (grade 6), Middle (grade 9), Senior High (grade 12)

Mathematics Standards

1. Use numbers, number systems, and equivalent forms (including numbers, words, objects, and graphics) to represent theoretical and practical situations.
2. Compute, measure, and estimate, to solve theoretical and practical problems, using appropriate tools, including modern technology such as calculators and computers.
3. Apply the concepts of patterns, functions, and relations to mathematics reasoning and problem solving.
4. Formulate and solve problems and communicate the mathematical processes used and the reasons for using them.
5. Understand and apply basic concepts of algebra, geometry, probability, and statistics to theoretical and practical situations.
6. Evaluate, infer, and draw appropriate conclusions from charts, tables and graphs, showing the relations between data and real-world situations.
7. Make decisions based on the collection, organization, analysis and interpretation of statistical data and the application of probability.

Cross-Cutting Expectations/Themes

- 21st Century demands and beliefs
- Exploration
- Problem solving
- Communication
- Connections

Science Standards

1. Explain how scientific principles of chemical, physical, and biological phenomena have developed and relate them to real-world situations.
2. Demonstrate knowledge of basic concepts and principles of physical, chemical, biological, and earth sciences.
3. Use and master materials, tools, and processes of major technologies that are applied in economic and civic life.
4. Explain the relationships among science, technology, and society.
5. Construct and evaluate scientific and technological systems using models to explain or predict results.
6. Develop and apply skills of observation, data collection, analysis, pattern recognition, prediction, and scientific reasoning in designing and conducting experiments and solving technological problems.
7. Evaluate advantages, disadvantages, and ethical implications associated with the impact of science and technology on current and future life.
8. Evaluate the impact on current and future life of the development of varied energy forms, natural and synthetic materials, and production and processing of food and other agricultural products.

Cross-Cutting Expectations/Themes

- Cause and effect
- Patterns and organization
- Energy and matter
- Systems and interactions
- Scale, models, and theories
- Continuity and change
- Structure and function
- Variation and diversity

Example of Content Standards and Benchmarks

Standard: Middle

Mathematics

Algebra: All students understand and apply basic concepts of algebra, geometry, probability, and statistics to theoretical and practical situations.

(p. 10)

Benchmarks for this Standard

1. Explain the concepts of variable, expression, and equation.
2. Represent situations and number patterns with tables, graphs, verbal rules, and equations and explore their relationships.
3. Write an expression, equation, or inequality that represents a theoretical or practical problem.
4. Use concrete, informal and formal methods to solve linear equations.
5. Apply algebraic methods to solve a variety of theoretical and practical situations and mathematical problems.

Standard: Middle

Science

All students demonstrate knowledge of basic concepts and principles of physical, chemical, biological and earth sciences.

(p. 43)

Benchmarks for this Standard

The student will:

1. Demonstrate an understanding of the basic concepts of science and technology: cause and effect; matter and energy; constancy and change; patterns and organization; structure and function; systems and interactions; variation and diversity; and scales, models, and theories.
2. Use knowledge and understanding of the basic concepts and principles of science and technology to describe or explain natural or human-made objects, events and phenomena.

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Rhode Island

Mathematics and Science Standards and Examples

Sources

Rhode Island Mathematics Framework K–12: Intellectual Power for All Students (1995)

Rhode Island Science Framework: Science Literacy for All Students (1995)

	CONTENT STANDARDS	BENCHMARKS/INDICATORS
Rhode Island's Term	"Content Standards" (Math) "Benchmarks" (Science)	—
Rhode Island's Definition	Math: State's standards "encompass" the NCTM curriculum standards. Science: Adopts the concepts of standards used in AAAS' Benchmarks	Through problem-solving situations, all students will construct their own understanding, so that by the end of __ grade they will: ...
Number	6 Mathematics, 4, 8, 10, 12 4 Science K–12	Math: 1-8 per standard; Science: 1-9 per standard K–2, 3–5, 6–8, 9–12

Mathematics Standards

1. Number Sense and Number Systems
2. Computation and Estimation
3. Measurement
4. Statistics and Probability
5. Patterns, Relations, and Algebra
6. Geometry

Science Standards

1. Nature of Technology
2. Physical Setting
3. Living Environment
4. The Human Organism

Cross-Cutting Expectations/Themes

Mathematics: Process Standards

- Mathematics as Problem Solving
- Mathematics as Communication
- Mathematics as Reasoning
- Mathematics as Connections

Science:

- Foundational Habits of Mind (group and individual)
- Applying Knowledge
- Acquiring Information
- Constructing Meaning

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Examples of Content Standards and Benchmarks

Standard: Grade 8

Mathematics

Patterns, Relations, Algebra (p. 73)

Benchmarks for this Standard

1. Solve linear equations.

Science

The Living Environment: Cells (p. 3C-25)

Benchmarks for this Standard

1. All living things are composed of cells, from just one to many millions, whose details usually are visible only through a microscope. Different body tissues and organs are made up of different kinds of cells. The cells in similar tissues and organs in other animals are similar to those in human beings but differ somewhat from cells found in plants.
2. Cells continually divide to make more cells for growth and repair. Various organs and tissues function to serve the needs of cells.
3. Within cells, many of the basic functions of organisms—such as extracting energy from food and getting rid of waste—are carried out. The way in which cells function is similar in all living organisms.
4. About two-thirds of the weight of cells is accounted for by water, which gives cells many of their properties.

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South Carolina

Science Standards and Examples

Source

South Carolina Science Academic Achievement Standards (Draft 1996)

In October 1995, the first draft of the South Carolina Academic Achievement Standards was released for public review. The draft standards were based on the content standards in the South Carolina Science Framework. Parents, students, teachers, the business community, and the general public need to clearly understand the standards and form a consensus regarding what all students are expected to know and be able to do.

	CONTENT STANDARDS	BENCHMARKS/INDICATORS
South Carolina's Term	"Area/Strands"	"Standards"
South Carolina's Definition	—	Standards are statements about what students should know and be able to do.
Number	4 areas K–12, 3 strands per area	3-4 per strand K–3, 3–6, 6–9, 9–12

Science Standards

Areas/Strands

- Living Things
- Earth and Space Systems
- Matter and Energy
- Applications

Standards: Process Skills

- Observe
- Classify
- Measure
- Infer
- Predict
- Design, Conduct, and Evaluate a Scientific Investigation
- Communicate

Cross-Cutting Expectations/Themes

The framework suggests four types of curriculum connections to other disciplines.

- Topical connections within an area of science and grade level group, e.g., respiration
- Topical connection across areas of science and grade level groups, e.g., dinosaurs
- Thematic connections across the areas, e.g., organization
- Strands within areas

Examples of Content Standards and Benchmarks

Standard: Grades 3–6

Living Things: Students should understand the processes of life and how interactions of organisms with their environment usually result in adaptations and change over time.

(p. 43)

Benchmarks for this Standard

In grades 3-6 students should know and be able to:

1. Understand the cellular basis of animal and plant structure and function.
2. Distinguish among major groups of organisms within kingdoms.
3. Identify and characterize organisms according to the functions they serve in the environment.
4. Investigate how organisms may adapt structurally, functionally, and behaviorally to different environments.

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South Dakota

Mathematics and Science Standards and Examples

Sources

South Dakota Mathematics Standards (1996)

South Dakota Science Standards (1996)

This content standards document is a result of over four years of dedicated work by a variety of individuals and projects in the state and supported by the South Dakota Department of Education and Cultural Affairs. The Standards writing process began in the spring of 1992 under the National Science Foundation Systemic Initiative. As the work progressed on the mathematics and science standards, the Department of Education was awarded a grant from the Secretary's Fund for Innovation in Education to write voluntary content standards in six academic areas. Over 700 copies of this draft were distributed to school districts and the general public for comment in 1995. Project staff members refined the standards into a comprehensive document with a common format and a consistent conceptual level in all content areas.

	CONTENT STANDARDS	BENCHMARKS/INDICATORS
South Dakota's Term	"Standards/Strands"	"Benchmarks"
South Dakota's Definition	Content standards are statements of what students are expected to know and be able to do in each of the subject matter areas ... an effort to describe the 'big ideas' or core content which should be learned by all students ... Content standards are not the school curriculum.	Not defined
Number	6 Mathematics strands, 7 Science standards K–12	16 per standard K–2, 3–4, 5–8, 9–12

Mathematics Standards

1. Algebra strand
2. Geometry strand
3. Measurement strand
4. Number Sense strand
5. Patterns, Relations, and Functions strand
6. Statistics and Probability strand

Science Standards

1. Nature of Science
2. Matter and Energy
3. Models
4. Structure and Function
5. Systems
6. Change and Constancy
7. Interrelationship of Science, Technology, Environment, and Society

Cross-Cutting Expectations/Themes

Mathematics

- Problem solving
- Communication
- Reasoning
- Valuing mathematics
- Mathematical literacy

Science

- Critical thinking skills
- Science literacy
- Valuing science
- Broad implications of science
- Use technology
- Collaboration

Example of Content Standards and Benchmarks

Standard: Grades 5–8

Mathematics

Algebra Strand: "South Dakota students will use the language of algebra to explore, describe, represent, and analyze number expressions and relations that involve variable quantities."

(p. 8)

Benchmarks for this Standard

Students will:

1. Analyze and model properties and interrelationships of algebraic concepts.
2. Apply algebraic concepts to solve a variety of problems.
3. Demonstrate an understanding of the abstract algebraic concepts of variable, number expressions, equality, and inequality.

Standard: Grades 5–8

Science

Structure and Function: "Students will use structures and functions to analyze the organization of matter."

(p. 8)

Benchmarks for this Standard

Students will:

1. Analyze the relationship between structure and function.
2. Analyze how changes could impact structure and/or function.
3. Construct and use classification systems based on structure and/or function.

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Tennessee

Science Standards and Examples

Source

Tennessee Science Framework K–12 (1995)

The Tennessee Science Curriculum Framework, K–12 is an attempt to change the way the Tennessee community of learners thinks about science. The community of learners includes students, families, educators, governmental organizations, businesses, industries, political leaders and all participants in society. The framework promotes learning science by doing science. The framework is organized around four components: Process of Science, Unifying Concepts of Science, Habits of Mind, and Science in Society. These four components are the foundation of the K–12 science curriculum in Tennessee.

	CONTENT STANDARDS	BENCHMARKS/INDICATORS
Tennessee's Term	"Themes" and "Standards"	"Benchmarks"
Tennessee's Definition	*Theme* is a statement which identifies a topic to be given special investigative consideration by the community of learners. *Standard* is a segment of information drawn from the theme that the community of learners perceives to have recognized and lasting value.	An instructional point of reference or target whose degree of attainment can be measured by analysis of the success and/or lack of success in meeting the related performance objectives.
Number	24 themes and 2-3 standards per theme	1-6 per standard K–2, 3–5, 6–8, 9–12

Science Standards

Process of Science Themes

1. Observing
2. Questioning
3. Collecting Data
4. Analyzing
5. Explaining
6. Communicating

Unifying Concepts of Science Themes

1. Scale and Model
2. Form and Function
3. Organization
4. Interactions
5. Change
6. Conservation

Habits of Mind Themes

1. Historical and Cultural Perspective
2. Assumptions
3. Estimation and Computation
4. Methods
5. Science and Technology
6. Creative Enterprise

Science in Society Themes

1. Attitudes
2. Personal Needs
3. Career Goals
4. Societal Needs
5. Economics
6. Politics

Examples of Content Standards and Benchmarks

Standard: Grades 6–8

Science

THEME: 2.1 Scale and Model—The development of models provides a conceptual bridge between the concrete and the abstract, while the use of scales allows for a comparison of differences in magnitude between the model and the desired form.

(pp.10-11)

Benchmarks for this Standard

Biological Science Grades 6–8

1. Models are often used to represent concepts of various magnitudes.

Grades 9–12

1. The cellular organelles, internal biochemical processes, and involved interactions can be described using appropriate models.
2. The structure of DNA and all cellular processes can be studied using models.

Texas

Mathematics and Science Standards and Examples

Source

Mathematics: Texas Essential Knowledge and Skills (1997)

This is the first of several drafts of the "Essential Knowledge and Skills (EKS)," a component of the state curriculum required by Senate Bill 1. The EKS reflects the required "foundation curriculum." The draft is written by a content team of specialists and community, higher education, business, and parent representatives.

Science: Texas Essential Knowledge and Skills (1997)

Since 1985 a common, statewide curriculum called "essential elements" has described what students in Texas are expected to have the opportunity to learn. It served as the basis for state-adopted textbook proclamations, for state-mandated tests, and as a guideline for teacher preparation. In 1995 the legislature directed the State Board of Education to adopt new "essential knowledge and skills" and to mandate that they become the required statewide curriculum. The current draft document details the essential knowledge and skills for science.

	CONTENT STANDARDS	BENCHMARKS/INDICATORS
Texas' Term	"Basic Understandings"	"Performance Descriptions"
Texas' Definition	... the fundamental concepts that comprise each area ... contain a statement on how students can use that concept in the real world ... describe the broad unifying ideas and understandings students are expected to acquire. Essential Knowledge and Skills articulate what all students need to know and be able to do.	Descriptions of the behaviors students should demonstrate in the classroom to demonstrate the Essential Knowledge and Skills students should attain at each grade level; will be used to guide any future state-level assessment measures.
Number (Math)	6 K–8 basic understandings, 15-20 knowledge/skills per grade and course	2-4 per knowledge/skills By grade in K–8; by course in grades 9-12
Number (Science)	6 basic understandings K–8 27-29 knowledge and skills per grade cluster, 10-15 for high school courses	2-4 per knowledge/skill PreK–2, 3–5, 6–8, High school

Mathematics Standards

For K–8

1. Number, operation, and quantitative reasoning
2. Patterns, relationships, and algebraic thinking
3. Geometry
4. Measurement
5. Probability and Statistics
6. Underlying mathematical processes

For High School Courses

1. Algebraic thinking and symbolic reasoning
2. Function concepts
3. Relationship between equations and functions
4. Tools for algebraic thinking
5. Underlying mathematical processes

Science Standards

Basic Understandings PreK–8

1. Science is a way of learning about the natural world.
2. Objects can be identified by their properties.
3. Organisms (living things) have varying needs for survival.
4. Change occurs and can be observed and measured.

Grade Level 3–5:

The student understands/demonstrates:

1. Simple scientific methods of inquiry
2. Everything is made up of matter
3. Basic needs for life
4. Interrelationships between past and present events and their effect on future events
5. Patterns of change exist
6. Forces can cause change

Grade Level 9–12

The Texas Essential Knowledge and Skills (TEKS) describes what students should know and be able to do for each of the following high school courses:

Level I Course Options

1. Scientific Analysis
2. Integrated Science
3. Biology
4. Environmental Systems
5. Space and Geoscience
6. Chemistry
7. Aquatic Science
8. Physics
9. Research and Design
10. Anatomy and Physiology of Human Systems
11. Medical Microbiology
12. Pathophysiology

Grade Level 9-12 (cont'd)

Level II Course Options

1. Advanced Placement (AP) Biology
2. AP Chemistry
3. AP Physics B and C
4. AP Environmental Science
5. International Baccalaureate (IB) Chemistry
6. IB Biology
7. IB Environmental Systems

Examples of Content Standards and Benchmarks

Standard: Grades 6–8

Mathematics

Basic Understanding: Patterns, Relationships, and Algebraic Thinking:

Mathematics can be used to describe dependent relationships between quantities. Students use algebraic thinking to describe how a change in one quantity results in a change in another; they connect verbal, numeric, graphic, and symbolic representations of relationships.

Knowledge/Skill: The student makes connections among the different representations of a relationship.

(p. 45)

Benchmarks for this Standard

1. The student translates freely among data in tables, graphs, equations, and verbal descriptions.

Science

Basic Understanding: Organisms (living things) have varying needs for survival. The student understands that there are basic needs for life.

Knowledge/Skill: The student knows that every organism requires a set of instructions for specifying its traits, and that the reproduction of these traits is essential to the continuation of every species.

Benchmarks for this Standard

10 a. The sixth-grade student, using appropriate references and tools, identifies cells as structures which carry on the many functions for sustaining life.

10 b. The seventh-grade student, using appropriate references and tools, describes asexual and sexual reproduction.

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Utah

Mathematics and Science Standards and Examples

Sources

Utah Mathematics Core Curriculum Grades 7–12 (1995)

Utah Science Core Curriculum Grades 7–12 (1995)

The core is designed to help teachers organize and deliver instruction. Both the mathematics and the science document present courses that secondary school students in the state of Utah must take to graduate. Each course description briefly describes the subject matter covered during a term and indicates what students are expected to know and be able to do in order to master the material presented in the course.

	CONTENT STANDARDS	BENCHMARKS/INDICATORS
Utah's Term	"Core" and "Standards"	"Objectives"
Utah's Definition	Core: what students should know and be able to do at the end of each course of study	A more focused description of what students need to know and do at the completion of instruction
Number	10-14 standards per math course 7 standards for science course, 7–12	40 objectives per math course 20 objectives per science course

Mathematics Standards

Elementary Algebra (as example)

1. Problem solving
2. Communication
3. Reasoning
4. Connections
5. Algebra
6. Functions
7. Synthetic Geometry
8. Geometry from an algebraic perspective
9. Trigonometry
10. Statistics
11. Probability
12. Discrete mathematics
13. Conceptual underpinnings of calculus
14. Mathematical structure

Science Standards (Grades 7–12 Core)

1. Use basic science process skills.
2. Use integrated science process skills.
3. Manifest scientific attitudes and interests.
4. Demonstrate awareness of the social and historical aspects of science.
5. Understand science concepts, principles, and systems.
6. Communicate effectively using science language and reasoning.
7. Understand the nature of science.

Cross-Cutting Expectations/Themes

Mathematics

- Thinking skills
- Information
- Interpersonal
- Basic skills
- Technology
- Assessment

Science

Eight Guidelines Used in Developing the Secondary Science Core

- Reflect the nature of science.
- Coherent
- Appropriate
- Encourage good teaching practices.
- Comprehensive
- Feasible
- Useful and relevant
- Encourages good testing practices

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Example of Content Standards and Benchmarks

Standard: Grade 7–12

Mathematics

Algebra standard: Algebra is a language through which most mathematics is communicated. The proposed algebra curriculum will move away from a tight focus on manipulative facility to include a greater emphasis on conceptual understanding, on algebra as a means of representation, and on algebraic methods as a problem-solving tool. Connections will be made to other representations such as numerical and graphing, and a graphing utility will be included.

(p. 21)

Benchmarks for this Standard

1. Represent situations that involve variable quantities with expressions, equations, inequalities, and matrices.
2. Use tables and graphs as tools to interpret expressions, equations, and inequalities.
3. Simplify and operate on expressions and matrices, and solve equations and inequalities, using properties of equality and inequality.
4. Appreciate the power of mathematical abstraction and symbolism.

Standard: Grade 7–12

Science

Students will understand structure and function of organisms (Grade 7).

(p. 3)

Benchmarks for this Standard

1. Evaluate evidence to support cell theory.
2. Investigate cellular structures and functions .
3. Compare levels of organization, structures, and functions within living things.

Vermont

Mathematics and Science Standards and Examples

Source

Vermont's Framework of Standards and Learning Opportunities (1996)

Vermont's standards are a brief but comprehensive set of materials that guide curriculum development in three broad "fields of knowledge" that include (1) arts, language, and literature; (2) history and social sciences; and (3) science, mathematics, and technology. Standards for each content area include both process—"vital results" and content standards in the required "fields of knowledge." This framework also includes a supplement, Core Connections: A How-to-Guide for Using Vermont's Framework. Vermont's framework affects virtually everyone involved in Vermont public education from PreK through grade 12.

	CONTENT STANDARDS	BENCHMARKS/INDICATORS
Vermont's Term	"Standards"	"Evidence"
Vermont's Definition	Standards raise expectations for all learners.	States how the standards can be demonstrated
Number	8 standards (integrating science, math, and technology fields of knowledge) PreK–4, 5–8, 9–12	1-10 per standard PreK–4, 5–8, 9–12

Mathematics, Science, and Technology Standards

1. Inquiry, experimentation, and theory
2. Mathematical understanding
3. Mathematical problem solving and reasoning
4. Systems
5. Space, time, and matter
6. The living world
7. The universe, Earth, and the environment
8. Design and technology

Cross-Cutting Expectations/Themes

"Vital results" cut across all fields of knowledge and, in the classroom, combine with field of knowledge standards. The following vital results standards apply to all grades and content areas:

- Communication
- Reasoning and problem solving
- Personal development
- Civic/social responsibility

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Examples of Content Standards and Benchmarks

Standard: Grades 5–8

Mathematics

Mathematical Understanding: Function and Algebra Concepts (p. 7.3)

Benchmarks for this Standard

This understanding is evident when students:

1. Discover, describe, and generalize a variety of patterns mathematically.
2. Understand variables in simple functions, especially linear and exponential functions; represent relationships with tables, graphs, and verbal or symbolic rules; analyze tables, graphs, and rules to determine relationships.
3. Explore solutions of unknown quantities in equations.

Science

Organisms, Evolution, and Interdependence: Students understand the characteristics of organisms, see patterns of similarity and differences among living organisms, understand the role of evolution, and recognize the interdependence of all systems that support life. (p. 57)

Benchmarks for this Standard

1. Identify, model, and explain the structure and function (e.g., cells, tissues, organs, systems) of organisms (e.g., plants, animals, microbes), both as individual entities and as components of larger systems.
2. Identify and use anatomical structures to classify organisms (e.g., plants, animals, fungi).

Virginia

Mathematics and Science Standards and Examples

Sources

Mathematics Standards of Learning for Virginia Public Schools (1995)

Science Standards of Learning for Virginia Public Schools (1995)

The standards are designed to establish accountability standards by setting "reasonable targets and expectations for what teachers need to teach and students need to learn," written in "clear, concise" language (p. iii). Standards are itemized by content area, following the pattern: "the student will ..." followed by a statement indicating what students are to accomplish. Also included are "minimum skills" in computer/technology that students are expected to achieve by the end of fifth and eighth grades.

	CONTENT STANDARDS	BENCHMARKS/INDICATORS
Virginia's Term	"Standards"	None
Virginia's Definition	Reasonable targets and expectations	None
Number	6 Mathematics, 6 Science (varies by grade)	6-30 per standard By grade, course

Mathematics Standards

1. Number and number sense
2. Computation and estimation
3. Measurement
4. Geometry
5. Probability and statistics
6. Patterns, functions, and algebra

Science Standards

Varies, but most grades include:

1. Scientific investigation, reasoning, and logic
2. Force, motion, and energy
3. Matter
4. Life processes
5. Interrelationships in earth/space systems
6. Earth patterns, cycles, and change
7. Resources

Example Content Standards and Benchmarks

Standard: Grade 8

Mathematics

Patterns, functions, and algebra (p. 16)

Benchmarks for this Standard

1. Write verbal expressions/sentences as algebraic expressions/equations.
2. Use algebraic terms appropriately in written and/or oral expression.
3. Solve two-step linear equations and inequalities... and solve practical problems requiring the solution of a two-step linear equation.
4. Identify and graph ordered pairs in the four quadrants of a coordinate plane.

Science

Life Science (p. 45)

Benchmarks for this Standard

LS. 2 ...Things are composed of cells

1. Cell structure and organelles
2. Similarities and differences between plant and animal cells
3. Development of cell theory
4. Cell division (mitosis and meiosis)

LS. 3 Cellular organizations

1. Cells, tissues, organs and systems
2. Functions and process of cells, tissues, organs and systems

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Washington

Mathematics and Science Standards and Examples

Sources

Washington Essential Academic Learning Requirements: Reading, Writing, Communication, Mathematics (1996)

Washington Essential Academic Learning Requirements: Science, Social Studies, Arts, Health & Fitness (1996)

The Commission on Student Learning—an 11-member state body—was directed by the state legislature to carry out the goals of the state's 1993 reform act. The standards were written by Commission-appointed subject matter committees that drafted, reviewed, and produced this volume and the accompanying volume that includes math "Essential Learnings." The introductory material indicates that these standards were designed to be "clear learning targets for students and teachers" (Introduction, p. 3) and that these academic standards "truly are for the public and [written] by the public." The document containing mathematic standards gives only the outline standards.

	CONTENT STANDARDS	BENCHMARKS/INDICATORS
Washington's Term	"Essential Learning"	"Benchmarks"
Washington's Definition	A statement of what students should know and be able to do at the completion of their K–12 education … [standards] serve as guideposts to school districts and give teachers flexibility in designing curriculum, teaching strategies, and plans for instruction.	… the necessary knowledge and essential skills students would be expected to achieve at approximately grades 4, 7, and 10.
Number	5 Mathematics; 4 Science	Averages 15-20 benchmarks per standard. Math: 4, 7, 10; Science: 4–5, 7–8, 10

Mathematics Standards

1. The student understands and applies the concepts and procedures of mathematics:
   - Number sense
   - Measurement
   - Spacial sense
   - Probability and statistics
   - Functions and relationships
2. The student solves problems using mathematics.
3. The student uses mathematical reasoning.
4. The student communicates knowledge and understanding in mathematical and every day language.
5. The student makes mathematical connections.

Science Standards

1. The student understands and uses scientific concepts and principles.
2. The student conducts scientific investigations.
3. The student uses effective communication skills and tools to build and demonstrate understanding of science.
4. The student understands how science knowledge and skills are connected to other subject areas and real-life situations.

Example of Content Standards and Benchmarks

Standard: Grade 7

Mathematics

The student understands and applies the concepts and procedures of mathematics: functions and relationships

(pp. 36-42)

Benchmarks for this Standard

Three benchmarks refer to linear algebra:

1. Knows how to symbolically represent equalities and inequalities
2. Understands and uses variables in simple equations, inequalities, and formulas
3. Knows how to set up and solve single variable equations

Standard: Grade 7

Science

Student understands and uses scientific concepts and principles: recognizes components, structure, and organization of the systems and the interconnections within and among them.

(pp. 19-25)

Benchmarks for this Standard

1. Knows the relationship among genes, chromosomes, cells, and hereditary information

Wisconsin

Science Standards and Examples

Source

Wisconsin Science Academic Standards (Second Draft, 1996)

The Science Academic Standards reflect the vision of change and reform in science education. They are grounded in the idea that both students and teachers learn together. The Science Academic Standards were developed by a writing team that consisted of classroom teachers, professional science educators, parents and citizens across the state.

	CONTENT STANDARDS	BENCHMARKS/INDICATORS
Wisconsin's Term	"Academic Standard"	"Performance Standards"
Wisconsin's Definition	Academic standards are models for academic education. They are organizational schemes and are to be connected together. The standards provide models for connections among the grades and from grade to grade.	No definition given
Number	9 Science K–12	5-6 per standard Elementary, Middle, High School

Science Standards

1. Nature of Science
2. Science Inquiry
3. Science Connections
4. Physical Science
5. Earth and Space Science
6. Life and Environmental Science
7. Science Communication
8. Science Applications
9. Science in Personal and Social Perspectives

Example of Content Standards and Benchmarks

Standard: Grade 8

Science

Students in Wisconsin will know and understand the characteristics and structures of living things, the processes of life, and how living things interact with each other and their environment.

(p. 7)

Benchmarks for this Standard

By grade 8, students will:

1. Investigate both structure and functions in living systems.
2. Understand reproduction and heredity.
3. Investigate the regulation and behavior of organisms.
4. Describe the interdependence of populations and ecosystems.
5. Recognize that diversity of species has been influenced by changes.
6. Recognize that changing earth conditions cause changes in biotic communities.

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List of Abbreviations

AAAS	American Association for the Advancement of Science
ASSM	Association of State Supervisors of Mathematics
CCSSO	Council of Chief State School Officers
CSSS	Council of State Science Supervisors
ED	U.S. Department of Education
IASA	Improving America's Schools Act
NCEST	National Council on Education Standards and Testing
NCTM	National Council of Teachers of Mathematics
NEGP	National Education Goals Panel
NRC	National Research Council of the National Academy of Sciences
NSF	National Science Foundation
NSTA	National Science Teachers Association
PSA	Policy Studies Associates
SSI	Statewide Systemic Initiatives
TIMSS	Third International Mathematics and Science Study

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References

American Association for the Advancement of Science. (1993). *Benchmarks for Science Literacy*. New York: Oxford University Press.

American Federation of Teachers. (1996). *Making Standards Matter: An Annual Fifty-State Report on Efforts to Raise Academic Standards*. Washington, DC: Author.

Blank, R.K., Pechman, E.M. (1995). *State Curriculum Frameworks in Mathematics and Science: How are They Changing Across the States?* Washington, DC: CCSSO, Policy Study Associates.

Bond, L. A., Roeber, E., & Braskamp, D.C. (1997). *Data on Statewide Student Assessment Programs in the United States*. Washington, DC: CCSSO; Oak Brook, IL: North Central Regional Education Laboratory.

Council of Chief State School Officers, State Education Assessment Center (1996). *Key State Education Policies*.

Council of Chief State School Officers. (1996). *Status Report of State Systemic Education Improvements*. Washington, DC: CCSSO/State Education Improvement Partnership.

Humphrey, D.C., Shields, P.M., Anderson, L. (1995). *Evaluation of the Dwight D. Eisenhower Mathematics and Science Education State Curriculum Frameworks Projects: First Report*. Menlo Park, CA: SRI International.

Humphrey, D.C., Shields, P.M. (1996). *A Review of Mathematics and Science Curriculum Frameworks*. Menlo Park, CA: SRI International.

Kapinus, B., McMillan, J. (1996). *States' Status on Standards: 1996 Update*. Washington, DC: CCSSO/ Curriculum and Instructional Improvement Project.

Knapp, M.S., Shields, P.M. eds. (1990, January). *Better Schooling for Children of Poverty: Alternatives to Conventional Wisdom (vol. 2)*. Washington, DC: U.S Department of Education, Office of Planning, Budget, and Evaluation.

Lee, V.E., Bryk, A.S., Smith, J.B. (1993). The Effects of High School Organization Influences the Equitable Distribution of Learning in Mathematics and Science. *Sociology of Education*, 70 (2). (Washington, DC: The American Sociological Association).

Lee, V., Smith, J., and Croninger, R. (1997). How High School Organization Influences the Equitable Distribution of Learning in Mathematics and Science. *Sociology of Education*, 70 (2). (Washington, DC: The American Sociological Association).

Massell, D., Kirst, M, Hoppe, M. (1997). *Persistence and Change: Standards-Based Systemic Reform in Nine States*. Consortium for Policy Research in Education: University of Pennsylvania.

National Center on Education Statistics. (1996). *Pursing Excellence: The Initial Findings from the Third International Mathematics and Science Study*. Washington, DC: Author.

National Council on Education Standards and Testing. (1992). *Raising Standards for American Education*. Washington, DC: U.S. Government Printing Office.

National Council of Teachers of Mathematics (1989). *Curriculum and Evaluation Standards for Mathematics Education*. Reston, VA: Author.

National Council of Teachers of Mathematics (1992). *Professional Standards for Teaching Mathematics*. Reston, VA: Author.

National Council of Teachers of Mathematics (1995). *Assessment Standards for School Mathematics*. Reston, VA: Author.

BEST COPY AVAILABLE

National Research Council. (1995). *National Science Education Standards.* Washington, DC: National Academy Press.

National Science Teachers Association. (1992). *Scope, Sequence, and Coordination of Secondary School Science. Vol. 1. The Content Core, a Guide for Curriculum Designers.* Washington, DC: Author.

Oakes, J. (1990). *Multiplying Inequalities: the Effects of Race, Social Class, and Tracking on Opportunities to Learn Mathematics and Science.* Santa Monica, CA: Rand Corp.

Porter, A.C. (1994). National standards and school improvement in the 1990s: Issues and promise. *American Journal of Education*, 102 (4). (Chicago: The University of Chicago).

Schmidt, et al. (1996). *A Splintered Vision: An Investigation of U.S Science and Mathematics Education.* By the National Research Center for the Third International Mathematics and Science Study.

Shanker, A. (1994, Fall). *Making Standards Count.* American Educator.

Smith, M.S., & O'Day, J. (1991). Systemic School Reform. In *The Politics of Curriculum and Testing.*

U. S. Space Foundation. (1996). *K-12 Integrated Education Standards.* Colorado Springs: Author.

Webb, Norman. (1997). *Criteria for Alignment of Curricular Expectations and Assessments in Mathematics and Science Education.* Washington, DC: CCSSO; National Institute for Science Education, University of Wisconsin-Madison.

Appendix A
Further Description of Study Design and Methodology

The CCSSO study of state curriculum frameworks and content standards in mathematics and science had three components: (a) interviews with state mathematics and science specialists to identify the status of state work on standards and frameworks, (b) qualitative panel review of standards and frameworks by an expert panel and state teams, and (c) concept mapping analysis of completed state documents by research staff.

Interviews with State Specialists

Staff at CCSSO and Policy Studies Associates contacted state specialists in mathematics or science by telephone in spring 1996. The interviews had two goals. We identified the current status of content standards or curriculum frameworks in mathematics and science, as well as the status of development of performance standards and student assessments based on the standards. We asked about current steps or plans of states in disseminating and implementing completed standards and frameworks. The completed interviews provided an up-to-date picture of standards and frameworks across the states.

Qualitative Review

The qualitative review included mathematics and science standards, frameworks, and related materials from 16 states. The review had two main purposes: to review the quality of state content standards or curriculum frameworks, and related state materials in order to provide expert comment and feedback to each of the participating states; and to identify key issues concerning the quality of standards and frameworks across states and make recommendations for how they can be improved. CCSSO contacted 40 states that completed new frameworks or standards in mathematics or science by 1996 and the state superintendent or commisisoner if the state wanted to participate in the review process. Sixteen submitted state standards or frameworks for review and agreed to send teams of two to four state representatives to participate. The participating states were: Alaska, Colorado, Illinois, Indiana, Kentucky, Louisiana, Maine, Mississippi, Missouri, Nevada, New Jersey, New Mexico, North Carolina, South Dakota, Texas, and Wisconsin.

The review panel included 21 national experts in the areas of mathematics and science education, standards and frameworks development, and education research and assessment (see list below). CCSSO selected the national experts to comprise the review panel, wrote the review questions and agenda based on expert advice, and organized the staff support, facilities, and states' participation. The review meeting was co-hosted by the National Institute for Science Education at the University of Wisconsin-Madison over a three-day period in August 1996.

The findings and issues raised in this report are based on patterns observed by the expert panelists and state representatives after conducting reviews of individual state frameworks or standards. Several common, or cross-state, findings were identified concerning the quality of state frameworks and standards and their application to schools. Issues raised through review of the work of 16 states are not necessarily representative of the current status of standards and frameworks in all states. However, they do provide an indication of patterns and trends among the states.

The states that participated in the review represent different state sources of support for developing mathematics and science standards and frameworks: five states had Eisenhower Math-Science Framework Development Grants from the U.S. Department of Education (AK, ME, NJ, LA, WI); nine had Statewide Systemic Initiative funding from the National Science Foundation (CO, KY, LA, ME, NC, NJ, NM, SD, TX); and, five had neither of these federal sources of support (IL, IN, MS, MO, NV). In addition, this group of states included large and

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small population states, and states from each region of the country. CCSSO maintains that the panel review results from the August review process have valid, and potentially useful, lessons for other states.

Concept Mapping Analysis

A third component of the CCSSO study design was a "concept mapping analysis." This analysis was completed by CCSSO and Policy Studies Associates research staff in Spring and Summer 1996. The analysis produced descriptive information on the characteristics and components of state standards and frameworks documents, and it is very useful for considering differences and similarities among state documents. A common set of definitions and categories were used to conduct the concept mapping analysis. The analysis staff had backgrounds in mathematics and science and were trained in the use of the mapping analysis procedures. The concepts analyzed included: purpose in state, vision/rationale, development process, standards and benchmarks, methods of communication, pedagogy, equity, policy linkages, uses of technology, and recommendations on materials and texts. The concept mapping analysis covered standards and frameworks completed by 32 states between 1994 and 1996. *(See Chapters Three and Four for results of the mapping analysis; see table, Chapter Two for a complete list of state frameworks and standards.)* The Concept Mapping Analysis "Definitions of Categories and Concepts" is in Appendix E.

Council of Chief State School Officers

"Issues in Quality of Mathematics and Science Frameworks/Standards and their Application in Schools"

Panel Participants, August 1996
Madison, Wisconsin
Meeting co-host: National Institute for Science Education

Expert panel

Charles Allan, Mathematics Specialist, Michigan Department of Education
Adrienne Bailey, Standards and Assessments, Council of Great City Schools, Washington, DC
Margaret Bondorew, Mathematics Education, Northeastern University, Massachusetts
Donald Chambers, Mathematics Education, University of Wisconsin-Madison
Benjamin Dixon, Deputy Commissioner, Connecticut Department of Education
Charles Doyle-Warren, Science Supervisor, Forest Hills School District, Cincinnati, Ohio
Janice Earle, Elementary, Secondary, & Informal Education, National Science Foundation
Joan Ferrini-Mundy, Mathematical Sciences Education Board, Washington, DC
Andrea Keim, Curriculum Frameworks, South Carolina Department of Education
Gerald Kulm, Project 2061, American Asociation for Advancement of Science, Washington, DC
Connie Laughlin, Mathematics Teacher, Muskego, Wisconsin
Julio Lopez-Ferraro, Systemic Initiatives, National Science Foundation
Megan Martin, Science Education/Assessment consultant, California
Curtis McKnight, Mathematics, University of Oklahoma
Michael Oliver, Science Education consultant, California
Harold Pratt, Science Education, National Research Council,Washington, DC
Helen Quinn, Stanford Linear Accelerator, Palo Alto, California
Cathy Seeley, Mathematics Education, University of Texas
Norman Webb, Mathematics Education/Assessment, Univ. of Wisconsin-Madison
Catherine Wilcoxson, Biological Sciences, Northern Arizona University
Abbie Willetto, Co-Principal Investigator, UCAN Rural Systemic Initiative, Colorado

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Council of Chief State School Officers

"Issues in Quality of Mathematics and Science Curriculum Frameworks and Standards and their Application in Schools"

Questions to be completed by Expert Panelists reviewing state frameworks, standards, and related materials, August 1996.

State: _____

State Documents reviewed:

Content of Mathematics and/or Science

1. To what extent is the state curriculum framework, standards, and other materials consistent with national standards in the discipline? (Math: NCTM, Curriculum and Evaluation Standards for Mathematics; Science: NRC Science Education Standards and AAAS Benchmarks for Scientific Literacy)

2. How does the content in the math/science framework or standards document differ from the main ideas and categories in the national discipline standards? What is omitted? What has been added?

3. Are the state standards for content sufficiently rigorous and specific for the intended levels of student learning? Why or why not? Are they inconsistent? (Cite specific examples.)

4. Do the state documents adequately address equity issues, i.e., high quality math and/or science for all students? Are there specific strategies or features for improving equity that you would recommend?

5. In your view, does the state have performance standards that set levels for expected student learning? Are the performance standards or levels consistent with the content standards? To what extent are the standards measurable?

Communication

6. Are the frameworks, standards and other materials written with language and style appropriate for the intended purposes and audiences?

7. Are the documents "readable" and "accessible" for local educators? For the public?

Implementation

8. What features of the standards, framework, and related materials will enable local educators to improve curriculum and teaching in mathematics and science? Is there sufficient depth of explanation? Do the state documents serve as a "bridge" between national and state standards and improving local practice?

9. To what extent are principles for content consistent with pedagogy, instructional strategies, vignettes, or sample problems outlined in the framework or other documents?

10. What evidence is there that the state standards or framework are being used to guide development of local curriculum?

Assessment

11. Do state assessments, or assessment plans, reflect the content standards and performance standards? What aspects of the standards are to be assessed by the state assessment system? What is your view of the relationship of standards to assessments?

12. Are there standards for assessment that address classroom assessment?

Other Components of Implementation

13. Are there models or standards for professional development of science or math teachers based on the principles of content standards? How consistent are they?

14. What state policies or system standards in the state materials support math or science education improvement?

15. What is your view of state plans and strategies for implementation of state frameworks and standards for math or science?

Appendix B
Examples of State Equity Strategies

ALASKA MATH/SCIENCE FRAMEWORK (p. 2-15)

THE STARTING POINT

Equity

> Schools must acknowledge the degree of influence that culture plays in learning and teaching.

Schools can no longer ignore the interaction of culture and school success. American schools have unjustly favored the students of the dominant culture by ignoring the norms and expectations of other cultures. Culture can be defined as the learned beliefs, understandings, world view, and norms acquired through ethnic, racial, lifestyle, gender, physical disability, or other group identities. Schools must provide equitable opportunities for students of all cultures. Curriculum cannot be culturally neutral, but it can be respectful of the contributions of all cultures, the characteristics of learners of different cultures, and the value of diversity to society. Schools must acknowledge the degree of influence that culture plays in learning and teaching. Although curriculum development committees are removed from actual classroom interactions that limit opportunities based on culture, these committees can affect policy and awareness. The following section provides suggestions for such actions.

Assumptions

- Alaska's students enjoy unprecedented opportunities to play, learn, and work in diverse and mutually respectful environments. Friendships dispel prejudices, and cooperative groups expose students to multiple perspectives.
- Education **equity** means more than the provision of equal access to courses, facilities, and programs. It also means designing schools to meet the diverse educational needs of all students through equitable school finance, the school communities, family empowerment, teacher preparation and training, and assessment.
- Attitudes are not created or changed by law or policies alone. Schools should take strong measures to ensure that all staff and students are treated with respect and positive personal regard. Biased or prejudiced attitudes against individuals or groups are unacceptable; they often lead to negative or discriminatory behaviors which impede school success. The development of equitable attitudes and behaviors in young people requires the immediate and dedicated attention of everyone concerned with social justice and the well-being of all people—school staff, parents, students, and community members.

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- No biased or derogatory language can be tolerated in any aspect of the school. Language is one of the most powerful influences in the development and reinforcement of attitudes.
- Interactions between teachers and students or among school staff often reflect unintended biases. Individuals sometimes treat each other differently based on their personal biases. Awareness, training, and commitment in this area can help break old, often unintended, and unfair ways of interacting.
- Materials often reflect bias in their content, illustrations, and language. Until commercial materials used in schools, such as textbooks, truly reflect the diversity and contributions of all groups in our society, bias-free supplemental materials must be used and skills to recognize bias and stereotyping must be taught and exercised.
- Good intentions alone are not an antidote for what happens to some children inside our schools. Gratuitous race and sex stereotypes must be eliminated and equitable school environments must be created. All students should be treated with respect and dignity by peers and teachers; and all students should share opportunities for meaningful friendships and participation and feel a sense of real progress and success in their school work.
- Appropriate attitudes, language, interactions, and good intentions must be supported by strong policies that give the message that equity is a priority and will be enforced.

What Curriculum Development Committees Can Do to Ensure Equitable Opportunities for All

Identify the cultures of the district and resources that reflect these cultures in the curriculum document: the diverse cultures' contributions in the different academic fields, their cultural histories, and their local members willing to be visible contributors to the educational community.

Provide professional development in a variety of teaching/learning styles appropriate to diverse students, such as **hands-on learning, inquiry-based learning, cooperative learning,** use of technology, and problem solving activities.

Conduct an **equity evaluation** of the school culture assessing staff attitudes, policies, school symbols, and individual awareness. Use the results as the basis of program, policy, and professional development decisions.

Research the level of participation of diverse students in the various offerings of each content area, looking for patterns and causes for variations and making suggestions to ensure equal access.

Arrange for peer observations or videotaping for self-checking to help teachers equitably distribute their attention, questions, and responses to all students in the classroom.

Maximize the time spent by students in heterogeneous groups. Minimize time spent in tracked or special-ability groups.

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Equity Principles*

"Educational excellence and equity for all" is a guiding principle of *New Directions*, Delaware's standards-based educational reform initiative. Excellence occurs when an instructional system provides each learner with a high level of challenge. Equity means that each learner is afforded the appropriate support he or she needs to succeed. The *New Directions Vision Statement*, adopted January 1995, states that educational reform in Delaware is focused on "improving student academic achievement" and preparing students to "lead full and productive lives as citizens and workers in the 21st century."

New Directions is based on the principle that all students can learn and consequently will be held to high academic expectations of knowledge and performance. Equity must be an integral part of standards-based educational reform if we are to improve academic achievement and prepare all students for the future. It is the responsibility of all Delaware educators to ensure that the content standards, curriculum, instruction, assessment and school practices are designed to provide diverse student populations with an equal opportunity to learn. To confirm this commitment to all student, the following **Equity Principles** are set forth:

1. All curriculum content standards and assessment materials are carefully reviewed to determine that they are free of bias and do not place some students at a disadvantage related to gender, race, ethnicity, economic status, native language, disability, or special gifts and talents.
2. Content standards, curriculum, instruction, performance tasks, and assessments are free of bias and accurately reflect the contributions of the diverse peoples that make up our society and the world.
3. Students with disabilities are held to the same academic standards as all other students. They are provided with instructional accommodations and other educational supports to afford them equal access to education. For the small percentage of students with severe disabilities who are in a life skills or functional curriculum, an alternative assessment system is utilized which is based on appropriate performance standards that are linked to overall standards.
4. All students can learn challenging content at significantly higher levels and are afforded an opportunity to meet academic standards at their individual pace.
5. Students whose first language is not English and who have been identified as Limited English Proficient are held to the same academic standards as all other students. They are provided with the appropriate accommodations that research indicates may be required for English language learners to attain fluency and meet rigorous content standards.

* Under review, will be adopted at the State Board of Education meeting July 20, 1995

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Equity Principles -continued

Achieving "educational excellence and equity" will be challenging. It will take an on-going commitment by all who have a stake in the success of our schools. Students, families, communities, educators and policy makers must all be held accountable for fulfilling their specific responsibilities to the educational process. Consequently, meeting these principles for equity requires that all stakeholders work together to implement the following initiatives:

Instruction

Teachers will use a variety of instructional techniques in the classroom to accommodate the various learning styles, learning rates, and strengths of diverse student populations. Educators will find ways to identify and remove school-based cultural barriers that contribute to the creation of disparities in student achievement. Classroom instruction will be based on individual student needs and allow students to progress as far and as fast as they are able.

Assessment

Assessments will be reviewed for cultural bias by teams of specially trained Delaware educators and community members. This process assures that assessments measure what students know and what they are able to do without creating an advantage or disadvantage based on the students' race, ethnicity, gender, disability, special gifts/talents, limited English proficiency, or socio-economic status. Assessments will allow students to demonstrate their skills and knowledge in multiple ways. Assessments will be aligned to classroom instruction and reflect real-life experiences of our diverse student populations.

School Improvement and Technical Assistance

Training and resources will be provided to Delaware education professionals to effectively deliver teaching strategies and other initiatives to meet the needs of diverse learners. Training and assistance will be provided to districts on strategies to enhance the recruitment of school staff that reflect the ethnic and racial diversity of our student populations.

School Profiles

Assessment data will be disaggregated for race, ethnicity, gender, disability, special gifts/talents, limited English proficiency, socio-economic status, and reported annually. This information will enable educators to review achievement data to determine whether diverse students have been provided equal access to education.

Leadership

Delawareans of diverse backgrounds will be equitably represented on *New Directions* commissions and committees charged with educational reform in order to provide a broad perspective on educational issues and assure that the needs of all learners are addressed. Families and community members from diverse backgrounds will play a significant role in educational decision making in the schools.

Research and Data Collection

The Department of Public Instruction will work collaboratively with the Delaware Educational Research and Development Center to develop a research agenda on equity issues and a statewide process to address related research questions. This information will then be disseminated to developers of standards and assessments and to schools.

Delaware must develop and use its resources wisely to meet the complex social, economic, and political challenges of the next century. Providing "educational excellence and equity" for every student is the best way to ensure that students become productive workers and community members.

School, State and District Policies

FAIR AND EQUAL TREATMENT OF TEACHERS MEANS EQUITABLE . . .

- sharing of responsibilities
- opportunities to attend conferences and workshops
- teaching assignments
- teaching load
- access to equipment and laboratories
- planning time
- opportunity to select instructional and classroom materials

If systemic change with regard to equity is to occur, policies must be developed that aggressively attack the subtle as well as the obvious prejudiced practices of the past, both within the school system and the community at large. The policies set at all levels must be actively pursued and supported.

> Equal opportunity must be viewed more hour-by-hour, rather than solely by policy decree, and it must begin very early, for the effects of unequal treatment and gender role stereotypes are already evident when children enter elementary school. Only active interventions will get students to reconsider their views of themselves, of mathematics and science, and of the options that they should consider open to them in adulthood. (Eccles, 1989, p. 56)

Shared state and local authority can be a hindrance to change. Efforts must be made to coordinate policies so that positive change can occur in a reasonable length of time. Too often, state directives are set aside without local implementation.

> From our perspective, the important policy question is not whether opportunity to learn standards should exist, but what combination of policies is most likely to break the lock of structural, political, and educational factors that have limited the effectiveness of past attempts to assure equal access to learning. (Elmore & Fuhrman, 1993, p. 33)

Equity Standards

School districts have policies that address issues of equity.

▪

Policies ensure that teachers and administrators respect diversity.

Strategies:

- Ensure that all teacher training programs within the state address equity issues in science and mathematics.
- Make certain that the state assumes a leadership role in developing and promoting policies of equity in the schools.
- Ensure that each school district enacts an equity policy relevant to students as well as staff and that the parents and community participate in the development of this policy.
- Have in place a written policy accommodating language minority (limited English proficient) students.
- Ensure that all school staff have the opportunity to influence formal and informal decision-making processes at all levels.
- Guarantee that all policies related to mathematics and science address the issue of equity with day-to-day applications.

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Equity Standard

Resources are targeted to addressing equity issues.

Strategies:

- Offer to all educators inservice training about how students from diverse groups learn.
- Ensure that parents and other community members are aware of equity issues and policies.
- Develop activities that can be done at home to encourage participation in science and mathematics activities.

Equity Standard

All projects and grants have criteria that address issues of equity.

Strategies:

- Address heterogeneous grouping and untracking in grant applications.
- Require that equity issues be part of the evaluation criteria for grants.

MEASURING UP

Equity Considerations for School, State, and District Policies

Has a grievance procedure been developed and publicized by the school for resolution of discrimination complaints by students and staff?

Is sensitivity to differences (including human relations skills) included among the criteria used to evaluate staff performance?

Do policies specifically encourage students in underserved groups to enroll in mathematics and science?

Has the school district ensured that staff who are knowledgeable about equity issues serve on all school committees?

Does the school have a procedure for dealing with parents who oppose their child's participation in mathematics and science activities and to alleviate any fears or concerns they may have?

Has inservice training for staff about strategies and procedures for overcoming bias and discrimination been offered?

Do policies include programs that encourage students and parents to value and promote self-esteem?

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Appendix C

Examples of Standards Communication in Curriculum Plans, Vignettes and Activities

ALASKA MATH/SCIENCE FRAMEWORK (p. 5-7)

Recommended Instructional Strategies for the Alaska Content Standards in Mathematics

The key elements of the Alaska Content Standards contain concepts and skills that students should master. Teachers will design integrated instructional units that address many of these key elements in an integrated fashion. As teachers design their units they should refer to the key elements, taking every opportunity to develop these new skills and concepts. The following charts suggest appropriate instructional strategies for each of the key elements of the Alaska Content Standards. References to detailed information on how to master these strategies are identified later in this chapter.

Math Content Standard A

All Alaska students will understand mathematical facts, concepts, principles, and theories.

Key Element	Instructional Strategies
1. Understand and use the concept of numbers, number systems and numeration including: counting numbers, whole numbers, integers, rational, irrational and complex numbers.	Manipulatives Performance Tasks/Centers Modeling
2. Select and use appropriate systems, units and tools of measurement, including estimation.	Manipulatives Performance Tasks/Centers Inquiry/Investigation/Experimentation
3. Perform basic arithmetic functions and make reasoned estimates. Select and use appropriate methods or tools for computation or estimation such as mental arithmetic, paper and pencil, calculator, computer.	Computer Data Collection Tools Peer or Cross-Age Tutoring Reciprocal Teaching
4. Represent, analyze, and use mathematical patterns, relation, and functions, using methods such as tables, equations, and graphs.	Computer Manipulatives Cooperative Learning
5. Construct, draw, measure, transform, compare, visualize, classify, and analyze the relationships among geometric figures.	Venn Diagrams Computer Manipulatives
6. Collect, organize, analyze, interpret, represent, and formulate questions about data. Make reasonable and useful predictions about the certainty, uncertainty, or impossibility of an event.	Computer Inquiry/Investigation/ Experimentation

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Math Content Standard B

All Alaska students will understand, select and use a variety of problem solving strategies.

Key Element	Instructional Strategies
1. Use computational methods and appropriate technology as problem-solving tools.	Computer Calculators
2. Use problem-solving to investigate and understand mathematical content.	Brainstorming Discussion Open Ended Questioning Manipulatives
3. Formulate mathematical problems that arise from everyday situations.	Field Studies Formulating Models Newspapers and magazines
4. Develop and apply strategies to solve a variety of problems.	Heuristics
5. Check the results against mathematical rules.	Reciprocal Teaching
6. Use common sense to interpret results.	Computer
7. Apply what was learned to new situations.	S/T/S Learning Cycle Model Field Studies
8. Be able to use mathematics with confidence.	S/T/S

Math Content Standard C

All Alaska students will understand, form and use appropriate methods to define and explain mathematical relationships.

Key Element	Instructional Strategies
1. Express and represent mathematical ideas using oral and written representations, physical materials, pictures, graphs, charts, and algebraic expressions.	Compare/Contrast Structures, Venn Diagrams, Matrices Open Ended Questions
2. Relate mathematical terms to everyday language.	Peer or Cross-Age tutoring Math Journaling
3. Develop, test and defend mathematical hypotheses.	Reciprocal Teaching Believing Questions Formulating Models Math Journaling
4. Clarify mathematical hypotheses through discussion with others.	Discussion Open Ended Questions

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Math - Intermediate Level: Dog Mushing

It is 8:00 a.m., Mrs. Titus greets her students at the door. The students are studying dog mushing. Today they will be discussing how to find out how mush it costs to raise a team of dogs.

Mrs. Titus: How many of you have a dog? (Show of hands.) What do you know about how much it costs for your family to keep a dog?

Student: I think we buy 50 lb. of dog food every two weeks.

Mrs. Titus: Are there other costs in caring for a dog?

Student: Every once in a while we have to take the dog to the vet.

Mrs. Titus: Do you know how much it costs to take your dog to the vet?

Student: No.

Mrs. Titus: Would it be possible for you to find out? If you were raising your dog to race in the XYZ dog race, do you think there would be other costs?

Student: I know a musher; I could ask.

The teacher makes a KWL chart during this discussion and fills out the "What We Know" section. She then solicits questions from the students for the "What We Want to Learn" section.

The student invited the musher to come into the classroom to answer questions about raising dogs.

MATH STANDARDS

E. Connections

A. Content

The teacher is using open-ended questioning strategies, making connections to real-life and to local culture, and using a graphic organizer. (KWL Chart).

MATH STANDARDS

A. Connections

E. Content

SCIENCE STANDARDS

A. Content

C. Nature of Science

The teacher is involving the community in the classroom.

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Mrs. Titus: What did we find out? (The teacher completes the "What We Learned" section of the KWL chart during this discussion.)

Student: I found out that there are lots more costs to raising a race dog than in caring for our pet dog.

Student: A race dog has to have special kinds of food, disease is a problem in kennels, the equipment for racing costs a lot of money, nice kennels have to be built, the musher has to work with his/her dogs everyday, and you have to buy special dogs.

MATH STANDARDS

A. Content

E. Connections

SCIENCE STANDARDS

D. Application

The teacher conducts continuous progress assessment through a KWL Chart.

Mrs. Titus: Can a musher do this as a hobby, or is it a full time job?

Henry Oyoumiak has the land and kennels to raise 50 racing dogs. How much will it cost him to acquire 10 dogs and take care of them in preparation for the XYZ dog race in 10 months. He will also use 10 dogs from another kennel.

Decide what information you need and collect that information. Determine how much it will cost him to raise and rent dogs for the race.

MATH STANDARDS

A. Content

B. Problem Solving

D. Reasoning

The teacher creates an application for the problem solving task.

Extensions:

The topic could be extended to focus of the optimum number of dogs to run in the XYZ dog race (within a certain budget) and the student's rationale for his/her choice.

This could require the use of a spreadsheet.

MATH STANDARDS

A. Content

B. Problem Solving

D. Reasoning

The students are developing useful technolgy tools.

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Sample Assessment

The following is an example of a Likert Scale. For more information see Chapter 6, Scoring Guides.

Student Name:

	No Evidence of Understanding	Some Evidence of Understanding	Effective Mastery
Distinguishes important from unimportant information.			
Finds source of accurate estimates of costs per dog per month.			
Recognizes whether or not answer is reasonable.			
Writes out complete answer to the problem.			
Appropriate use of multiplication and addition.			

Science Level 2: Spruce Bark Beetle

Students had previously:

- inventoried the tree and shrub species of the local forest,
- investigated the relationship between diameter and circumference,
- designed and built a tool to measure the diameter of trees,
- explored the concept of plot/sample size by establishing the boundaries for a one-acre plot and discussing the feasibility of sampling this size plot.

I'll meet you outside in two minutes. Don't forget your plot sampling data sheet, your compass, your tool for measuring the diameter of trees on your plots, or your coats.

Students' acting as foresters, are off to the local woods to collect data on forest composition and health.

One team member identifies a tree for data collection; another measures tree diameter and height; a third records data; and the fourth team member observes and makes a determination of the tree's health

Student: Mr. Holt (a State Forester), why would this tree be dead while the one next to it still looks healthy?

Teacher: If you'll look here, you'll see boring dust. This is the place where a spruce bark beetle entered the tree.

Student: You mean something that made that tiny hole killed this huge tree?

SCIENCE STANDARDS

B. Inquiry

C. Nature of Science

Learning takes place outside the classroom given flexible scheduling. Role performances mimic real life/ careers.

SCIENCE STANDARDS

A. Content

B. Inquiry

C. Nature of Science

D. Application

The students use the processes of science, with appropriate instruments, to design and carry out investigations.

Working in cooperative teams fosters positive interdependence.

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The next day in class, students wanted to know more about the spruce bark beetle.

Teacher: Has anyone ever seen a spruce bark beetle? What do they look like?

Student: I've seen one - they are about 2 cm long and they bite!

Student: Aren't they the one [sic] that stink when you step on them?

Teacher: You'll find specimens of adult, larval, and pupal forms of the spruce bark beetle under the microscopes. Your task is to prepare an Informational Document which details the problem of spruce bark beetles in our community. We will analyze our data to quantify the problem. Identify your audience and prepare a document appropriate for this group. Here is the rubric that will be used to assess your document.

SCIENCE STANDARDS

A. Content

C. Nature of Science

D. Application

Constructivism involves finding out what the students already know, exposing their preconceptions, and building on their prior experiences

Assigning tasks, like preparation of an Informational Document, along with providing resources, like specimens and agency documents, provides context for students to explore the topic.

Student: Look what I found in my backyard!

A student takes pieces of bark from a bag and shows her classmates where the beetles have underscored the bark.

To complete this unit of study, students will participate in a simulation as landowners on the Kenai Peninsula. As landowners, they will devise a management plan to best deal with the spruce bark beetle infestation, given various perspectives and degrees of bark beetle infestation.

SCIENCE STANDARDS

D. Applications

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Standard #1 **Nature and Application of Science and Technolgy**

Grades 4–5

Science as Inquiry

By the end of fifth grade students should know that:	Sample activities include:
1. Curiosity about nature and the world around us leads scientists to ask questions in a way that requires scientific investigation in order to develop an explanation. The breadth and style of this investigation depend on the questions asked.	Ask reasonable scientific questions about a topic of interest and decide what information is needed to answer these questions. For example, how does the amount of sunlight a plant receives affect its growth? What can the class do to reduce cafeteria waste? Do some substances dissolve in water faster than others? Is there always a full moon on the same day of each month?
2. In science, answering certain questions requires observation and simple testing to generate additional information and enable a more complete investigation.	Plan and conduct a simple investigation to answer testable questions. Choose or develop techniques for obtaining data that can be used to answer the questions. Ask additional questions based on this investigation.
3. The ability to observe and gather data is enhanced by using a variety of instruments.	Demonstrate increasing sophistication in the use of instruments to make measurements and to obtain more complete detail.
4. Collaboration, communication, and comparison are important parts of science. Graphs, charts, maps, equations, and oral and written reports can be used to share the results of a scientific investigation and facilitate discussion about it.	Compare the results of individual or group investigations. Critique the investigative strategies and results and discuss the observations, measurements, methods, selection of materials, and differences that exist in these.

Science, Technology, and Society

1. Science consists of many disciplines such as chemistry, biology, geology, and physics, and in the broadest sense, can be viewed as the collective efforts by people in these disciplines to organize, describe, and understand the natural world.	The following sample activity applies to this content statement.

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Standard #1	Nature and Application of Science and Technolgy
By the end of fifth grade students should know that:	**Sample activities include:**
2. Technology applies knowledge to solve problems and to change the world to suit us better. Technological innovation plays an important role in improving the quality of life. Such innovation involves scientific disciplines as well as other disciplines such as engineering, mathematics, medicine, and economics in order to create practical, cost effective solutions to problems and opportunities.	Compare present day technologies (methods and equipment to perform a specific function) to those of the past such as washing machine/washing board, refrigerator/icebox, automobile/horse-drawn carriage, and television/radio or compare technologies used in this country to those used in other parts of the world (e.g., heavy equipment/elephants, electric stove/cooking over a fire). Discuss the impact these technological differences have had on the quality of life.
3. Technological development improves the quality of our life immensely and continues to do so in many areas such as medicine, communications, transportation, and agriculture. However, not all development is perfect, uniformly beneficial, or equally available to everyone.	Examine a variety of old technological devices (e.g., wooden potato masher, apple peeler, washing board) and speculate for what the object was used, how it helped people, and what problems it caused.

History and Context of Science

Men and women of all ages and from diverse cultures are involved in a multitude of scientific endeavors in the search to better understand nature. These people practice science in many ways and at various depths and levels of complexity. This search continues to add new knowledge to society's understanding of the world.	Read a variety of short stories that present science as human endeavor in which men and women from different cultures have participated. Use a variety of resources (e.g., books, films, guest scientists, field trips) to describe the many different kinds of science-based occupations and the diversity of individuals involved.

Support teachers and evaluate successes and failures

12. Support new units for a year; collect feedback.

Support includes buying materials and consumables, setting up "user-groups" for each grade level where teachers can share information about the new teaching they're doing. It also includes establishing some form of support for teacher questions, and evaluating the unit. Find out if the units are teachable, likable, and—especially—*effective* in helping students meet the objectives.

Support also includes helping teachers change the way they teach if necessary. Peer coaching or demonstration teaching are key ways to help teachers learn how to teach in new ways. See the section on professional development, pp. 61-77, for additional suggestions.

13. Continue to add new units as teachers become comfortable with new ways of teaching. Adjust the curriculum framework (the scope and sequence) as necessary. Adjust the professional development plan as necessary.

A five-year plan for improving science teaching and learning

Year 1	Year 2	Year 3	Year 4	Year 5
Become familiar with the *Michigan Essential Goals and Objectives for Science Education*. (The Content Standards & Benchmarks) **Funding source:** Eisenhower **Resource:** Math/Science Centers	Look for teaching materials that teach to the appropriate objectives. **Resource:** Math/Science Centers	Buy, distribute and re-stock equipment for 1st-year units.	Buy, distribute and re-stock equipment for 2nd-year units.	Inservice all teachers on new units and begin teaching them. **Funding:** Eisenhower
Develop a draft K-12 scope and sequence (district curriculum framework)	Use new materials to develop unit plans for at least one unit per grade ("1st-year units").	Inservice all teachers on 1st-year units and begin teaching them. **Funding:** Eisenhower	Inservice all teachers on 2nd-year units and begin teaching them. **Funding:** Eisenhower	Support all units, collect feedback. Revise as needed.
Place Objectives/ Content Standards and Benchmarks in scope and sequence.	Have some teachers pilot 1st-year units before adopting for whole district.	Support units, design and use assessments.	Support units, design and use assessments.	
Share district curriculum framework with "stakeholders" and get feedback. Present to the Board. Talk to the PTA/PTO. Put articles in school newsletters. Then revise curriculum framework as needed.	Infuse interdisciplinary materials and activities into 1st-year units. Have field-test teachers work cooperatively to develop equipment lists for units.	Begin to develop unit plans for 2nd-year units within each grade; acquire new instructional resources as needed for the new units. **Funding:** Eisenhower **Resource:** Math/Science Centers	Begin to develop unit plans for 3rd-year units within each grade; acquire new instructional resources as needed for the new units. **Funding:** Eisenhower **Resource:** Math/Science Centers	
Develop a 5-year plan for unit planning, purchasing equipment, in-service, support, & evaluation.	Edit and distribute 1st-year units to all teachers.	Pilot 2nd-year units before adopting them.	Pilot 3rd-year units before adopting them.	

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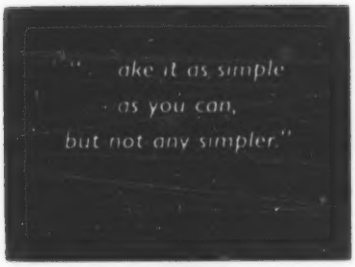
MICHIGAN SCIENCE EDUCATION GUIDEBOOK (p. 16)

The Elementary Curriculum



The elementary science curriculum is, at best, an articulated set of experiences that acquaint students with the natural world and the ways that scientists view it. The curriculum is usually built from blocks or units of instruction. These may be composed of commercially available units, chapters from textbooks that have been infused with hands-on activities, sets of activities passed from teacher to teacher, or special projects of various kinds.

The charts on the following pages are examples that show how complete K-4 curricula might be organized. The one below is a sample made up of several units purchased commercially (ordering information is listed in the appendix); state objectives are listed explicitly for each unit.

One possible K-4 district curriculum framework (scope and sequence) using commercially available units

	Kindergarten	1st Grade	2nd Grade	3rd Grade	4th Grade
Life Science Units	GEMS *Tree Homes* GEMS *Ladybugs*	STC *Life Cycle of Butterflies* OR STC *Organisms*	GEMS *Terrarium Habitats*	MDE *Running on Plants*	STC *Microworlds*
obj's	LT 1, 2, 4; LT 1, 3; Eco 1, 2; Evo 2; C1, 2, 5; R 2, 4	LT 1, 3; Evo 2; C 1, 2, 5; R 2, 4	Eco 1, 3, 4; LT 1, 4; Evo 2; C 1, 2, 5; R 2, 4	LT 1, 3, 5; C 1, 2, 4, 5; R 2, 4, 5	Cells 1; C 1, 2, 3, 5; R 3, 5
Physical Science Units		MDE *Constructing Toys & Concepts*	FOSS *Balance & Motion*	STC *Sounds* WOBS *Light, Color & Shadows*	STC *Chemical Tests* AIMS *Mostly Magnets*
obj's		ME 1; CM 1, 3; MO 1; C 1, 2, 5; R 1-4	MO 1, 2, 3; C 1, 2, 3, 5; R 2-4	WV 1, 2; C 1, 2, 3, 5 R 2-4 WV 3, 4, 5; C 1, 2, 5; R 2-4	ME 1, 3; CM 1, 2; C 1, 2, 5 ME 5; C 1-6
Earth Science Units	WOBS *Water & Ice*	WOBS *Rocks, Sand, & Soil*	MDE *Weather in Our Neighborhood*	STC *Rocks & Minerals* District: *Astronomy*	MUCC (K-4) *Project WISE*
obj's	Hyd 1, 4; C 1, 2, 5; R 2, 4	G 2, 4, 5; C 1, 2, 5	AW 1, 2, 4; C 1-6; R 2-5	Evo 1; G 1-6 SS 1, 2	G 6; Eco 5; C 1, 2, 5, 6

For a list of state science objectives abbreviations, see p.22. See the resource section on Instructional Materials for a key to the abbreviations used for the teaching units.

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MICHIGAN SCIENCE EDUCATION GUIDEBOOK (P. 20)

The Secondary Curriculum

he textbook is not the curriculum.

Constructing a district curriculum framework for the secondary grades is an essential activity for the entire science staff. The process of laying out and looking for connections between the courses, projects, and units taught at each grade helps everyone consider exactly what knowledge and skills you intend to teach, and how they can be organized across the grades. It leads away from a reliance on the textbook and its table of contents as the only guide to your district's curriculum, and helps you consider whether your courses adequately address the state science standards and benchmarks (goals and objectives.)

Warren Consolidated Middle School Curriculum framework using textbook chapters and supplemental materials

	5th Grade	6th Grade	7th Grade	8th Grade
A	Constructing & Reflecting **Science Process Unit** *Hello* (Nat'l Geo.) 8 wks	Waves & Vibrations **Wave Energy** (MacMillan #33) *Windows on Science* (Optical Data) 8 wks	Universe, Galaxy & Solar System, Evolution **Origin of the Universe, Solar System & Earth-Moon System** (MacMillan #37) *Windows on Science* (Optical Data) 7 wks	Constructing & Reflecting (Prentice-Hall) *Product Testing* (Consumer Reports) 7 wks
B	Motions of Object **Forces at Work** (MacMillan #25) *World in Motion* (SAE) 10 wks	Energy **Electricity and Magnetism** (MacMillan #28) *Taking Charge* (NSTA) 6 wks	Geosphere, Evolution **Earth Changes Through Time** (MacMillan #35) *Convection* (GEMS) 4 wks	Matter **Matter: Building Block of the Universe** (Prentice-Hall) *Solutions/Pollution & Toxic Waste* (CEPUP) 15 wks
C	Living Things, Heredity, Evolution, Cells **Plants & Animals** (MacMillan #12) *GROWLAB* (NGA) 9 wks	Matter **Changes in Matter** (MacMillan #28) *Taking Charge* (NSTA) 10 wks	Geosphere, Evolution **Earth Changes Through Time** (MacMillan #40) *Windows on Science* (Optical Data) 8 wks	Energy **Motions of Objects** (Prentice-Hall) *Methods of Motion* (NSTA) 8 wks
D	Weather/Atmosphere **Air, Weather and Climate** (MacMillan #27) *Weather* (Nat'l Geo.) 9 wks	Cells, Living Things, Heredity, Evolution **Simple Organisms and Viruses** (MacMillan #31) *Small Things* (ESS) 10 wks	Hydrosphere, Evolution, Motion of Objects **Oceans in Motion** **Groundwater** (MacMillan #34) (CEPUP) *The Water Planet* (NSTA) 8 wks	Energy **Heat Energy** (Prentice-Hall) *Evidence of Energy* (NSTA) 6 wks
E		Cells, Living Things, Heredity, Evolution **Plant Kingdom** (MacMillan #30) *GROLAB* (NGA) 6 wks	Living Things, Matter/Energy, Geosphere, Hydrosphere **Earth's Ecosystem** (MacMillan #36) 9 wks	
F	Review of 5th grade MDE goals and objectives 3 wks	Review of 6th grade MDE goals and objectives 3 wks	Review of 7th grade MDE goals and objectives 3 wks	Review of 8th grade MDE goals and objectives 3 wks

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MICHIGAN SCIENCE EDUCATION GUIDEBOOK (P. 22)

One sample curriculum framework for middle grades, based on MEGOSE topics (the content standards), showing sources of instructional materials. No grades are suggested in this table, giving you the option to place each unit wherever your curriculum committee chooses.

	Middle School Physical Science	state benchmarks/ objectives	**Middle School Earth Science**	state benchmarks/ objectives	**Middle School Life Science**	state benchmarks/ objectives
	Matter & Energy		**Weather & Atmosphere**		**Plants & Cells**	
Units and possible instruc. mat'ls:	LHS GEMS *Chemical Reactions*	ME4, C7, 8, 10, 11, 12	LHS GEMS *Global Warming & the Greenhouse Effect*	AW 5, 8; Eco 11; CM 7; C7, 8, 10, 11, 12	MDE *Lives of Plants*	Cells 3, 4; LT 6, 7, 8; C7, 8, 10, 11, 12; R8
	STC *Electric circuits*	ME15; C7-12; R8;			STC: *Plant Growth & Development*	LT6, 7, 9; C7, 8, 10-12
	STC *Magnets & Motors*	ME16; C7-12; R8	LHS GEMS *Acid Rain*	R6, 7, 8, 9		
	LHS CEPUP *Refrigeration*	ME8, 13; CM4, 7; C7-12; R8, 9				
	Motions of Objects		**Hydrosphere**		**Animals**	
Units and possible instruc. mat'ls:	AIMS *Machine Shop*	MO4, 5, 6, 7 C7, 8, 9, 10, 11, 12	LHS CEPUP Groundwater: *The Fruitvale Story*	Hyd 7, 8; C7, 8, 10, 11, 12; R6, 7, 8, 9	NSTA *Earthworms*	Evo 2; LT 6, 9; C7, 8, 10-12; R6, 8
			NSTA *Project Earth Science: Meteorology*		NSTA *Pillbug Project*	Evo 2, LT6; C7, 8, 10-12 R6, 8
	Changes in Matter		**Geosphere**		**Ecology**	
Units and possible instruc mat'ls:	MDE *Hard As Ice. Steamed Up!*	H5, ME8, 12, CM1, 4, 8; C7, 8, 10 R6, 10	LHS CEPUP *Waste Hierarchy*	CM 6, 7; H7 C7, 8, 11; R6, 8, 9; G6 (elem)	IES *Eco-Inquiry*	Eco 6-12; C7, 8, 10-12; R6, 8
	LHS GEMS *Acid Rain*	AW8; Eco 11; CM7; C7, 8, 10, 11, 12; R6-9				
	LHS CEPUP *Plastics in Our Lives*	ME11, 12; CM7, 8; Eco 11; C7, 8, 11, 12; R6-9				
	Investigating Chemical Processes; Your Island Factory	CM5, 7; Eco 11; C7, 8, 11, 12; R6, 7, 9				
	Investigating Hazardous Materials	CM6, 7; Eco 11; C7, 8, 11, 12; R6, 8, 9				
	Household Chemicals	ME10; CM5; Eco 11 C7, 8, 10, 11, 12; R8				
	Waves & Vibrations		**Astronomy**		**Human Biology** or **Heredity & Evolution**	
Units and possible instruc. mat'ls:	LHS GEMS *Hot Water, Warm Houses*	ME8, 13; CM4; C7-12; R6, 7, 8, 9	LHS GEMS *Sun, Moon & Stars*	SS 4, 5		
	Franklin Institute *Light & Color*	WV8, 9	*NSTA Project Earth Science: Astronomy*	(obj's not reviewed)		

A guide to abbreviations for the state science objectives.

C	Constructing New Knowledge	Her	Heredity	G	Geosphere
R	Reflecting on Sci. Knowledge	Evo	Evolution	Hyd	Hydrosphere
Cells	Cells	Eco	Ecosystems	AW	Atmosphere and Weather
LT	Organization of Living Things	ME	Matter and Energy	SS	Solar System, Galaxy & Universe
		CM	Changes in Matter		
		MO	Motion of Objects		
		WV	Waves and Vibrations		

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PART I

Entering the Profession

This part, which embodies *Framework* standards for student learning, describes preservice experiences and activities, certification procedures, and hiring practices for teachers of mathematics and science. It examines essential preparation of prospective teachers in mathematics and science content, skills and pedagogy. Suggesting important university and field experiences in both traditional and alternative paths to mathematics and science teaching, this section also explores certification options.

Preparation in Science Content and Skills

Those preparing to teach science should learn science content using inquiry methods because inquiry-based courses provide learners direct contact with scientific tools, methods and habits of mind. In teacher preparation programs meeting the spirit of this Framework, preservice teachers acquire skills necessary to support scientific investigations: skill in using technology, mathematical analysis, the laboratory and the field. Individually and in research groups they regularly engage in data gathering, analysis and interpretation, exploring and discussing open-ended, practical problems. To gain an understanding of science beyond the scope of isolated investigations, preservice teachers learn best by actively investigating phenomena, reading scientific papers and developing critical thinking skills. Prospective teachers of science must be able to make personal sense of findings which either are consistent with or which challenge currently accepted scientific understanding. Courses preparing future teachers should examine the implications of science and technology on community and world issues.

At all levels, teachers of science should possess this knowledge and these competencies:

- **Fundamental facts and concepts.**
  Understand the fundamental facts and concepts of the life sciences, physical sciences, environmental science and earth/space science, as they are necessary to support the Content Standards of the *Maine Curriculum Framework for Mathematics and Science*.
- **Nature and skills of scientific inquiry.**
  Understand the nature and skills of scientific inquiry and be able to apply the skills and processes of inquiry to pose questions; design ways to investigate those questions; use measurement and observation tools such as microscopes, telescopes, electronic probes, and analytical balances to collect data; analyze data qualitatively and quantitatively (using computer and mathematical methods); and interpret data.

- **Connections.**
  Make conceptual connections among the sciences, with mathematics and other disciplines, and with everyday phenomena and problems.
- **Science, technology, society.**
  Understand past and present relationships among science, technology, society, human issues and cultural values.
- **Responsible laboratory practices.**
  Understand and use procedures for safe handling of materials and equipment. Learn and practice safe laboratory techniques. Know how to dispose of materials safely, handle living things ethically and use the environment thoughtfully.

More specific information about what teachers should know and be able to do in order to teach science at primary, intermediate, middle and secondary levels appear in the Performance Indicators listed for each Content Standard in Framework Section II and under Certification in this section (p. 14).

Preparation in Mathematics Content and Skills

Those preparing to teach mathematics should be actively engaged in doing mathematics. They should have experiences in problem-solving, communicating mathematical concepts and procedures in mathematical language, reasoning, and exploring various connections in mathematics: connections between mathematical concepts, how those concepts are related to other disciplines, and how the concepts are applied in the world outside of school. The application of mathematical methods in scientific investigations is one such connection.

The mathematics preparation of teachers should incorporate preparation in content, skills and preservice experiences as suggested in the NCTM *Curriculum and Evaluation Standards for School Mathematics, NCTM Professional Standards for Teaching Mathematics* and Framework Content Standards. Teacher candidates should understand and use tools for learning mathematics, including calculators, graphing calculators, computers and other tools that provide images for conceptual understanding.

The preparation of future mathematics teachers should foster the disposition to do mathematics, the confidence to learn mathematics independently, and fluency in the language and symbolism of mathematics.

At all levels, teachers of mathematics should possess this knowledge and these competencies:

- **Fundamental concepts and skills.**
  Understand the concepts and have the mathematical skills described in Framework Content Standards (Section II).

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- **Nature and skills of mathematical inquiry.**
  Understand the nature, skills and processes of mathematical inquiry (pattern recognition, conjecture, induction, deduction and the role of proof) to reason mathematically and support decision making through problem identification, analysis and interpretation. Use the tools of mathematics (physical models, manipulatives, calculators, computers, measuring tools and design tools) to develop conceptual understanding and solve problems.

- **Connections.**
  Make connections among mathematics concepts, with mathematics and other disciplines, and with everyday phenomena and problems.

- **Mathematics in society.**
  Understand mathematics as an ongoing human enterprise and be able to describe the role of mathematics in past and present societal endeavors.

More specific information about what teachers should know and be able to do in order to teach mathematics at primary, intermediate, middle and secondary levels appears in the Performance Indicators listed for each Content Standard in Framework Section II and in Certification in this section (p. 14).

Preparation in Science and Mathematics Pedagogy

In addition to content knowledge, teachers of mathematics and science need pedagogical knowledge, including understanding of how children learn and knowledge of recent research and best teaching practices. It is especially important that post-secondary science and mathematics faculty model these practices because research in learning to teach suggests that teachers frequently teach as they have been taught. Future teachers must also develop the analytical skills necessary to translate educational and scientific research into good classroom practice. Furthermore, they need practice in action research — learning to examine their classroom experiences in search of findings which can be used to improve teaching.

Future mathematics and science teachers should be prepared to:

- **Respond to the learning needs of all students.**
  Effective teachers are able to design activities which match their students' developmental levels. They can develop short-term and year-long goals with and for learners, prepare lessons that are designed for a variety of learning styles, and provide experiences that consider students' diverse cultural and social backgrounds, gender, and special needs.

- **Promote active, engaging, experiential learning.**
  Effective teachers provide students with "hands-on, minds-on" scientific and mathematical experiences whenever appropriate.

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Structuring lessons that promote active involvement of all students, these teachers skillfully design learning tasks based on problem-solving and/or inquiry. They use a variety of techniques to support student inquiry and construction of knowledge, and they know how to help students take increased responsibility for their own learning.

- **Assess student achievement and readiness for learning.** Effective teachers use a variety of methods, including both alternative and traditional assessment tools, to assess student progress and performance. They encourage and support student self-assessment as well. They know how to use the results of formative and summative assessment in productive ways to guide teaching and improve student learning.
- **Create a positive learning environment in the classroom.** Effective teachers provide a physically and emotionally safe environment for all learners. By supporting students in constructive risk-taking, they help learners build confidence and a sense of personal worth.
- **Support collaboration in learning.** Effective teachers create learning environments in which students can work cooperatively and collaboratively. These teachers model collaborative learning by learning with and from their students, showing that learning is a valuable shared enterprise in which individuals are responsible for their own learning and for the learning of a group or team.
- **Help students communicate in mathematics and science.** Effective teachers provide frequent opportunities for students to use the language of mathematics and science by using and encouraging oral and written discourse in the classroom.
- **Connect mathematics and science to the student's world.** Effective teachers draw from the students' experiences to create relevant learning situations that involve practical problem-solving. This can include grappling with community problems or issues which lead students to generate hypotheses, investigate problems, collect data, interpret results and draw conclusions. Teachers drive home the relevance of science and mathematics learning by finding and using community resources to support class activities. This includes contact with practicing mathematicians and scientists from diverse backgrounds and information about the range of possible careers in mathematics and science.
- **Use tools and technology for instruction in mathematics and science.** Effective teachers use a variety of tools such as calculators, computers, and digital probes — not only as audiovisual aids, but also for collecting and interpreting data. Using physical models, visual aids and multimedia resources to demonstrate concepts, these teachers encourage students to use tools and technology to construct knowledge and develop understanding.

Appendix D

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Appendix E

Concept Map of Standards and Frameworks: Definitions of Categories and Concepts

State Education Agency Subject(s) of Framework

TITLE	Official and complete title of framework or standards document(s)
DATE OF DOCUMENT REVIEWED	
STATUS OF FRAMEWORK	Classify the current status in terms of one of the following four phases:

Developing or working draft:	Document is in a pre-distribution and development phase; it is not yet disseminated for formal review beyond a limited circle of writers or experts.
Review draft:	Document is a completed draft that is being formally disseminated for comment and final revisions.
Adopted:	Document serves as official guidance, mandate, or policy.
Other Status:	

MAIN COMPONENTS OF DOCUMENT: Components present

Content standards:	content knowledge and skills students are expected to know and be able to do in math or science, often by grade level
Performance standards (or outcomes):	description of the levels of proficiency to which content standards shall be attained by students
Pedagogy/Instructional strategies:	pedagogical approaches, ideas, procedures, and processes of teaching recommended for use with curriculum
Links to Policies and Enabling Conditions:	policies or guidelines for assessments, professional development, curriculum design and organization, materials and texts, school and system support, technology, facilities
Implementation/Professional Development Plan for state:	
Framework document includes one subject or multiple subjects:	

SINGLE VS. MULTIPLE SUBJECTS:

Related Documents	key state-designed and disseminated documents, in addition to the framework, related to the curriculum framework or standards (referenced or identified from other information). Indicate author(s), title, and publication date.

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State Context

A. State's Vision for Mathematics/Science:

(1) Specific to one subject vs. broad, general

(2) Contains specific information about needs, interests of state vs. general statement

(3) Page # for Vision statement

B. Intent or Purpose of the Framework/Standards:

Indicate which of the following concepts best describe the rationale, goals, or purpose, as stated in the framework; add any concepts the state identifies that are not described by these overarching statements.

- Develop student knowledge and habits of mind.
- Modernize and change instruction.
- Design recommended curricula and instructional resources.
- Insure equity and access for all students.
- Make or implement assessment/evaluation policy.
- Involve parents, business, and other community members.
- Other

C. Major Sources:

Major national documents or reports, or state documents referenced in the opening sections of the framework that establish the vision and define the conceptual foundation for science/mathematics education.

- NCTM Curriculum & Evaluation Standards, Teaching Standards, Assessment Standards;
- NAS/NRC National Science Education Standards; AAAS Benchmarks;
- or other states' frameworks or reports; or, other studies or reports.

(1) Reference page numbers for national documents

(2) Characterize how they used—modeled closely after national document; frequent references; listed as resource

(3) List other states that are referenced as sources.

D. Mandates or State Initiatives supporting frameworks and standards:

- State funding initiatives
- Legislative or State Board mandates, rules, or regulations
- External funding—from federal, nonprofit agencies, etc.

(List the funding sources/agencies)

E. Target Audiences:

The key groups that the framework was designed to inform, assist, or advise—those expected to make most immediate and regular use of the framework to carry out their mission and primary responsibilities. (ref. page numbers)

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- Teachers: teachers in all subjects and for all grades or special groups; and certified support personnel such as media specialists, counselors, etc.;
- School and district curriculum planners: curriculum and instructional supervisors, designers, or writers
- School administrators
- Assessment developers
- Board members
- Parents
- Business or Industry partners
- Other community constituents

F. Key Development Activities:

Major steps that best describe phases, events, or processes that were used in completing the current edition of the framework.

(1) Indicate if Development process is described in document.

(2) If YES, list steps described:

- Expert panel(s) and/or advisory committee(s)
- Reviews and analyses of other similar or model documents
- Suggestions, ideas, exemplars from teachers, educators and subject specialists
- Teacher participation in writing and editing for the framework's text (including writing of suggested standards)
- Successive drafts were written, reviewed, and modified
- Focus groups for review/discussion of drafts
- Pilot study in districts and/or classrooms
- Wide dissemination within schools and throughout communities and the state
- Other: (Indicate other activities that differ from those listed above.)

Standards

A. Content Standards:

Categories or headings that organize subject content and indicate (in bold) the term(s) used for the categories, e.g., strands, standards, themes, disciplines, etc. List only the broad outline; include example of detail in the sample Standards in the next section. Describe the state's definition and uses of content or performance standards as specified in the framework document.

- *Definition:* quote or paraphrase, page reference
- *Number of standards*
- *Grade levels/clusters of standards.* If content categories differ greatly across grade levels, separately list content clusters for each grade level or group.

preK K 1 2 3 4 5 6 7 8 9 10 11 12

Example of content standard (state term) for algebra/life science:

> **Quote full or partial standard. Select examples from the middle grades: in mathematics select algebra; in science select a life science topic (living things, preferably); provide page references.** **(p. #)**

B. Benchmarks/indicators: Next level of detail below standards.

Definition: Term used for this level

Number of benchmarks per standard

Grade levels/clusters of this level

Example of benchmarks for a middle grades math/science standard:

C. Cross-Cutting Themes:

Concepts for organizing and implementing curriculum content that transcend framework's major content organizers, including processes, themes, attitudes, habits of mind, etc. They appear repeatedly across several components or sections of the framework, in various content areas and topics.

Content Standards	specify what content knowledge and skills students will know and be able to do upon completing particular grades or courses; state clearly the knowledge and skills to be taught, and what developmental level content is to be presented.
Performance Standards	specify usually in conjunction with a method of assessment—how good is "good enough." Performance standards gauge the degree to which content standards have been attained by individuals or groups, indicating the nature of the evidence and the quality of student performance on agreed upon tasks or measurement instruments.

Performance Standards

A. State's definition and term for performance standards:

Where they are found

Name of document, page

How related to content standards

- Short quote on definition, page #
- Number of performance standards; grade clusters

Example of performance standard (state term) for algebra/life science:

> **Quote full or partial standard of a performance standard that is consistent with the content standard defined above.**

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B. Performance standards are designed and described to be used for developing:

- External accountability/state assessment
- End-of-course assessment
- Student accountability/classroom assessment

Describe use(s) for state (from interviews).

Assessment

How is assessment related to standards?

- Classroom or instructional assessment
- Accountability

Examples of assessments, p. #

Types of exercises/tasks described or modeled

Communication

Methods of presenting and communicating content used the document to illustrate the recommended curriculum content or pedagogical practices. (Indicate page #'s for good examples.)

- *Vignettes:* illustrative classroom scenarios or essays that describe teaching, situating instruction in a context that demonstrates the give and take among children and their teachers and shows with considerable descriptive detail how teachers define in practice specific content areas and instructional approaches. Vignettes often include dialogue.
- *Models or examples of instructional practice:* "How to" examples of techniques or thumbnail sketches of practice. Compared with vignettes, models are shorter, more static, and they do not attempt to reflect classroom context, discourse, or exchanges that occur among teachers and students.
- *Activities and/or instructional tasks:* lists or outline of activities or tasks, reported with a minimum of detail, surrounding context, give or take, or dialogue
- *Diagrams, graphics, photographs:* visuals used to model or illustrate the instructional activities, tools, structures, patterns, or approaches
- *Other unique features (ways of presenting content, etc.):*

Linkages to Policies and Enabling Conditions

Linkages of Content Standards to policies and recommended enabling conditions:

Extent of alignment of framework's vision, content, standards, and pedagogy with other state education policies, or with policy decisions that are left to district or school levels; policies that enable teachers and schools to improve math/science

Record the linkages within one of the following two dimensions:

(1) Current and existing policy links are reported within the document.

(2) Policy linkages are proposed and/or recommended.

- Professional development
- Assessment for external accountability
- Selecting, developing, or using materials and textbooks
- Teacher preparation and certification
- Student support services
- School and curriculum organization, decision making, uses of time, district and school support
- Technology integration
- Involving community representatives, parents, and business leaders in planning, review, and policy-making committees
- Facilities

Other Documents providing policy linkages to content standards:

Equity

Equity:

Indicate the ways the framework document addresses racial/ethnicity, gender equity, inclusiveness, and attentiveness to handicapping conditions in the curriculum. Framework clearly describes or illustrates state recommendation for any one equity element that is checked.

(1) Where/in what sections is equity treated?

(2) How is it treated? Cite examples, p.#

- *Rationale and vision statements:* (e.g., importance of all students learning math/science in K–12; how framework will aid this goal)
- *Vignettes, activities, and sample problems:* (e.g., examples are multi-racial/ethnic, cross-gender, and refer to education for culturally diverse, handicapped, and limited-English speaking students, and describe diverse teaching and learning situations)
- *Instructional strategies, Curriculum organization:* (e.g., including content and instructional techniques that nurture the needs of students from varied backgrounds, experiences, cultures, and communities
- *Curriculum organization and course structure:* (e.g., de-tracking curriculum; integrated courses, teacher assignments, involving multicultural communities in teaching and learning, etc.)
- *Materials selection and distribution:* (e.g., guidelines for materials selection reflect high standards for all groups)
- *Assessment approaches:* (e.g., strategies that are sensitive to racial/ethnic, gender difference, minimize bias, and maximize opportunities for students to demonstrate their knowledge in various ways)
- *Staff development:* (e.g., proposes strategies to reach educators with few development opportunities)
- *Teacher preparation:* (e.g., designs that prepare teachers to teach math/science content to diverse student groups)
- *Hiring practices:* (e.g., examples of incentives for increasing numbers of minority teachers and administrators)

- *Community and business involvement:* (e.g., suggested mechanisms for increasing the involvement of diverse groups)
- *Policies and recommendations:* (e.g., state policies that promote equity and inclusiveness in teaching, curriculum, assessment, hiring, etc.)

Pedagogy

The approach to teaching and learning—the instructional strategies, processes, or activities recommended, proposed, or modeled—and the means by which these ideas are presented. Pedagogy categories are based on the NCTM, Curriculum and Evaluation Standards (1989) and AAAS, Benchmarks (1993).

Record extent to which state document suggests, models, or describes the following pedagogical practices:

Constructive and active lessons: students actively engage with content, materials, tools, and/or with peers to build understanding of mathematical and scientific ideas, solutions, or explanations.

Technological applications: students use various technological tools (calculators, including those that graph, and computers) to derive mathematical and scientific solutions.

Multiple assessment strategies: teacher observations, conferences, self-assessments, student journals; projects, experiments, constructions; writing, tasks and real-world problems to solve; formal and informal tests; oral presentations, etc.

Discourse, dialogue, and argument: verbal representations of the logic underlying mathematical and scientific ideas; strategies call upon students to discuss, prove their point of view, probe one another's thinking, as well as the teacher's, etc.

Flexible uses of time and facilities: varying time blocks, classroom spaces, libraries, laboratories, etc. are suggested as resources for learning mathematics and science.

Working with a mix of tools, manipulatives, text books, and resources: activities and tasks suggest ways to involve students in a wide range of mathematical and scientific problem-solving tools and materials

Experiments and multiple solutions: tasks demonstrate ways that mathematics and science are incorporated into applied contexts through problem solving, experiments, and experiences that lend themselves to alternative solutions with no single "best" answer or solution strategy.

Representation, including writing, mapping, diagramming, graphing, etc.: students are encouraged to explain mathematics and science in various formats, including pictures, diagrams, spreadsheets, models, maps, etc. as well as verbally.

Other Framework Components

Major sections or chapters of state framework not addressed by preceding categories.